TOPOGRAPHIC AND GEOLOGIC

ATLAS

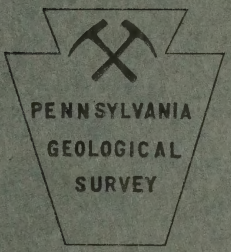
of

PENNSYLVANIA

No. 65

PUNXSUTAWNEY QUADRANGLE

ASHLEY



U. S. GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

PENNSYLVANIA DEPARTMENT OF FORESTS AND WATERS
R. Y. STUART, SECRETARY

TOPOGRAPHIC AND GEOLOGIC SURVEY
GEORGE H. ASHLEY, STATE GEOLOGIST

TOPOGRAPHIC AND GEOLOGIC
ATLAS OF PENNSYLVANIA
SHEET 65, PUNXSUTAWNEY AREA, PLATE I

Base from U. S. Geological Survey topographic map of Punxsutawney quadrangle, Pennsylvania Surveyed in cooperation with the State of Pennsylvania in 1902-1904.

MAP OF THE PUNXSUTAWNEY QUADRANGLE, PENNSYLVANIA

Showing Topography

Scale $\frac{1}{62500}$

1 0 1 2 3 4 Miles

1 0 1 2 3 4 5 Kilometers

ENGRAVED MAR. 1906 BY U.S.G.S.

A. HOEN & CO. BALTIMORE.

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TOPOGRAPHIC AND GEOLOGIC
ATLAS OF PENNSYLVANIA
SHEET 65, PUNXSUTAWNEY AREA PLATE II

EXPLANATION

SEDIMENTARY ROCKS

Qal — **Alluvium**
(in flood plains of present streams)

Csb, Ccm, Cum — **Conemaugh group**
(shale, thin limestone, some red shale, thin coal beds locally workable, and coarse thick-bedded sandstones; containing Saltsburg, Csb, *and Upper Mahoning,* Cum, *members)*

Ca, Ccl — **Allegheny group**
(chiefly light and dark gray clay shale with variable beds of coarse gray sandstone and several valuable coal beds. Upper Freeport coal on top, Brookville coal at base; containing Clarion, Ccl, *and other sandstone members)*

Cpv — **Pottsville series**
(thick-bedded sandstone with shale in the middle carrying thin coal, locally workable)

Base from U. S. Geological Survey topographic map of Punxsutawney quadrangle, Pennsylvania Surveyed in cooperation with the State of Pennsylvania in 1902-1904.

MAP OF THE PUNXSUTAWNEY QUADRANGLE, PENNSYLVANIA

Showing Areal Geology

Geology by Geo. H. Ashley, F. B. Peck, and E. F. Lines, 1905-1907 for the U. S. Geological Survey, in cooperation with the Topographic and Geological Survey Commission of Pennsylvania.

A. HOEN & CO. BALTIMORE

Scale $\frac{1}{62500}$

1 ½ 0 1 2 3 4 Miles

1 ½ 0 1 2 3 4 5 Kilometers

Contour interval 20 feet.
Datum is mean sea level.

1926

U. S. GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

PENNSYLVANIA DEPARTMENT OF FORESTS AND WATERS
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TOPOGRAPHIC AND GEOLOGIC SURVEY
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TOPOGRAPHIC AND GEOLOGIC
ATLAS OF PENNSYLVANIA
SHEET 65, PUNXSUTAWNEY AREA PLATE III

EXPLANATION

CONEMAUGH

Qal — Alluvium (in flood plains of streams.)

Csb, Ccm, Cum — *Area underlain by Upper Freeport or E coal and clay and by the rocks above E coal. Contains the Saltsburg, Csb, and Upper Mahoning, Cum, sandstones.*

ALLEGHENY

Upper Freeport or E coal — *Outcrops of rocks between the Upper Freeport or E coal and clay at the top and the Lower Freeport or D coal.*

Ca3 — Lower Freeport or D coal

Ca2 — *Outcrop of rocks between the Lower Freeport or D coal and clay at the top and the Lower Kittanning or B coal. The Freeport coals have been eroded from this area.*

Ca1 — Lower Kittanning or B coal

Ccl — *Outcrop of rocks between the Lower Kittanning or B coal and clay at the top and the Brookville or A coal. Contains the Clarion sandstone, Ccl. The Freeport and Kittanning coals have been eroded from this area.*

POTTSVILLE

Br — Brookville or A coal

Cpv — *Outcrop of rocks below the Brookville or A coal.*

COAL, CLAY AND LIMESTONE

- Him — Harlem coal
- Am — Ames limestone
- Bkt — Bakerstown coal
- Br. Cr. — Brush Creek coal
- Mah — Mahoning coal
- U.F. — Upper Freeport or E
- L.F. — Lower Freeport or D
- U.K. — Upper Kittanning or C
- L.K. — Lower Kittanning or B
- Vp — Vanport limestone
- Br — Brookville coal

SYMBOLS

- Ss — Sandstone quarry
- Commercial coal mine
- × — Small coal mine or prospect
- ▲ — Coal outcrop or bloom
- cl — Commercial clay mine
- cl × — Clay prospect
- cl △ — Clay outcrop
- fl △ — Flint clay outcrop
- ls △ — Limestone outcrop
- Gas well
- Show of gas
- ◇ — Dry hole

SANDSTONE

Csb, Cum, Ccl

Outcrop of massive sandstone suitable for foundations, bridge abutments, and general building.

Cum—Upper Mahoning sandstone
Csb —Saltsburg sandstone
Ccl —Clarion sandstone

1750 — Structure contours on Upper Freeport or E coal.

Contour interval 50 feet

Base from U. S. Geological Survey topographic map of Punxsutawney quadrangle, Pennsylvania Surveyed in cooperation with the State of Pennsylvania in 1902-1904.

MAP OF THE PUNXSUTAWNEY QUADRANGLE, PENNSYLVANIA

Showing Mineral Resources and Structure

Scale 1/62500

1 0 1 2 3 4 Miles

1 0 1 2 3 4 5 Kilometers

Contour interval 20 feet.
Datum is mean sea level.

1926

A. HOEN & CO. BALTIMORE.

Geology by Geo. H. Ashley, F. B. Peck, and E. F. Lines, 1905-1907 for the U. S. Geological Survey, in cooperation with the Topographic and Geological Survey Commission of Pennsylvania.

PENNSYLVANIA
GEOLOGICAL SURVEY
FOURTH SERIES

TOPOGRAPHIC AND GEOLOGIC

ATLAS

of

PENNSYLVANIA

NO. 65

PUNXSUTAWNEY QUADRANGLE

GEOLOGY AND MINERAL RESOURCES

By
GEORGE H. ASHLEY

Prepared in cooperation with the United States Geological Survey

Department of Forests and Waters
R. Y. Stuart, Secretary

Topographic and Geologic Survey
G. H. Ashley State Geologist

LETTER OF TRANSMITTAL.

R. Y. Stuart, Secretary,
Department of Forests and Waters.

Sir:

I have the honor to submit for printing my report on the Geology and Mineral Resources of the Punxsutawney Quadrangle. The field work for this report was done principally in 1905 under a cooperative agreement by the U. S. Geological Survey and the Pennsylvania Topographic and Geologic Survey Commission. The field work was done by the writer, assisted by Frederick B. Peck, professor of geology at Lafayette College, and Edwin F. Lines of the U. S. Geological Survey. It was not completed in 1905 owing to the early recall of Professor Peck and the demands of other work upon the writer, who at that time had general supervision of all the Federal geologic work going on in the eastern coal fields of the United States. The writer made a number of subsequent trips to the field, closing up gaps in the original field work. Increase of administrative duties and later his removal to Tennessee as State Geologist delayed the completion of the report. The text, however, was completed in 1917 but has awaited funds for publication since that time. In its present form advantage has been taken of some additional information obtained through coal mine inspectors of the Department of Mines of Pennsylvania.

The Punxsutawney region has long been one of the active coal mining centers of the coal fields of Pennsylvania. Because of its location it has been a large source of supply to New York and New England States. At the time it was examined some of the largest mines of the State were in this area. Since the original field work was completed there has been a large development in this field, but many areas containing coal of good thickness still lie undeveloped.

Respectfully submitted,

Geo. H. Ashley

State Geologist.

May 10, 1925.

PREFACE.

The Topographic and Geologic Atlas of Pennsylvania presents the results of the Survey's "thorough and extended survey of the State for the purpose of elucidating the geology and topography of the State." (Act of June 7, 1919, establishing Survey.)

The Act further provides: "The Survey shall disclose such chemical analysis and location of ores, coals, oils, clays, soils, fertilizing and other useful minerals, and of waters, as shall be necessary to afford the agricultural, mining, metallurgical, and other interests of the State, a clear insight into the character of its resources. The Survey shall also disclose the location and character of such rock formation as may be useful in the construction of highways or for any other purpose."

The results of the surveys may, in accordance with the provisions of the Act, be presented in the form of several series of publications as follows:

1. Topographic Atlas Sheets 16 x 20 inches: The surveys for these sheets are made by the State in cooperation with the U. S. Geological Survey, each paying half the costs. The engraving, printing and distributing of these sheets is done by the U. S. Geological Survey at Washington, D. C.

2. The Topographic and Geologic Atlas: Maps and texts showing and describing the topography, geology and mineral resources of the State by quadrangles. This series continues and supplements all "folios" and "economic bulletins" of Pennsylvania already published by the U. S. Geological Survey in cooperation with the State. Each quadrangle is an area about 17½ miles long from north to south and about 13½ miles wide from east to west and is represented by a single map or sheet. The quadrangles are numbered from west to east and from north to south. Sheet No. 65 is in the seventh row from the western edge, and the fifth sheet from the northern boundary of the State. The reports constituting the atlas will bear the same numbers. The following figure shows the geographic position of the Punxsutawney Quadrangle, Sheet 65, and the areas described in geologic folios and bulletins of the United States Geological Survey. (The numbers on folios and bulletins of the U. S. Geological Survey do not follow this system.)

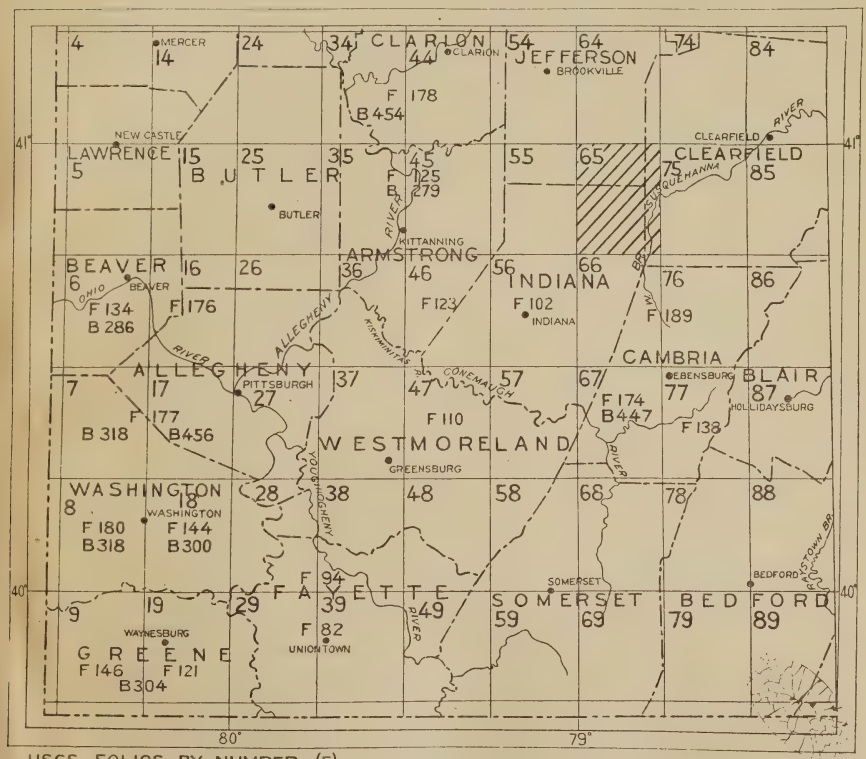
3. County Reports: As the Atlas Sheets and reports are highly detailed and somewhat technical, a series of County Reports will present the general facts in more popular language, and

on maps without topography. These reports will also review the broader aspects of the subject, and in particular will present the detailed Soil Maps and Soil Reports.

4. Mineral Resources: These reports are confined to describing and showing the location of a single mineral resource over the State, with studies of the technology, including the mining, preparation and marketing of the minerals.

5. Underground Water Resources: In general, water resources will be discussed in the County Reports or in the Topographic and Geologic Atlas, but general studies on underground water supplies will follow in a fifth series of reports.

6. Soil Reports: In general, Soil Maps and Reports will accompany the County Reports, but general maps or discussions on soil conditions will fall in this series.



U.S.G.S. FOLIOS BY NUMBER (F)
U.S.G.S. BULLETINS BY NUMBER (B)

FIGURE 1. Index map of western Pennsylvania. The location of the Punxsutawney quadrangle is indicated by the darker ruling (No. 65).

CONTENTS

ILLUSTRATIONS.

Geology and Mineral Resources of the Punxsutawney Quadrangle, Pennsylvania.

By George H. Ashley

Assisted in the field by Frederick B. Peck and Edwin F. Lines.

INTRODUCTION.

One of the most active coal mining centers in Pennsylvania has been for many years between Punxsutawney and Reynoldsville, a little west of the central part of the State. In 1905 more than 5,000,000 tons of coal were mined in this field. A few miles southeast of this area is the Glen Campbell field, a much smaller coal development, which, in 1905, produced nearly 1,000,000 tons of coal, and between the two are the Rossiter and Clover Run fields, the former of which produced around 750,000 tons for many years. Surrounding these developed areas are large areas of undeveloped coal. The present report describes the local or detailed stratigraphy, structure, and mineral resources of a quadrangular region including part of the Punxsutawney-Reynoldsville field, the Glen Campbell and other developed fields, and a large area of undeveloped territory lying adjacent to these fields. The report forms Part 65 (Punxsutawney quadrangle) of the Topographic and Geologic Atlas of Pennsylvania.

Location and area.

In accordance with a settled policy of the Pennsylvania Geological Survey and the United States Geological Survey, the region covered by this detailed report consists of a quadrangular area bounded by parallels and meridians. This quadrangle is known as the Punxsutawney quadrangle, from the town of that name in its northwestern part. The quadrangle lies a little west of the center of the State, in western Clearfield County, southeastern Jefferson County, and northeastern Indiana County. It lies between parallels 40° 45′ and 41° 00′, and meridians 78° 45′ and 79° 00′. (See fig. 1). It has a length from north to south of about 17½ miles, and a width from east to west of about 13¼ miles, with an area of 225.90 square miles. It includes the towns of Punxsutawney, Big Run, Glen Campbell, Ross-

iter, Clayville, Lindsey, Adrian, Walston, Anita, Crawfordtown, Richmond (Rochester Mills post office), Burnside, McGees Mills, Arcadia, Gipsy, Smithport (Horton post office), Gettysburg (Hillsdale post office), Deckers Point, Wilgus, Urey, and Harmony, besides some thirty smaller hamlets and post offices. Many of these are mining towns and therefore of a more or less transient character. Punxsutawney, the principal town, had a population in 1920 of 10,311. Its business importance is increased by its serving as headquarters for most of the mining operations of the nearby towns.

Number and kind of mineral resources.

At the present time coal is preeminently the principal mineral resource of the area. This large development is due to the high grade of the coal which has good minable thickness. The coal mined north of Punxsutawney and extensively coked is one of the purest coking coals in the State. Mining in the Punxsutawney field has been on a large scale, some of the mines there having produced more than 1,000,000 tons a year. Coking operations have likewise ranked among the largest in the State. At Walston there are, or were, 657 ovens in a single bank nearly 1¼ miles long, and at Adrian are 516 ovens in two banks.

The coals are of high grade, averaging about 65 per cent fixed carbon; 25 per cent volatile matter; 3 per cent moisture before air drying; 4 to 9 per cent ash; 0.6 to 2.5 per cent sulphur, but averaging nearer the lower figure. Chemically, where the sulphur content is low, the coals agree closely with the best grade of coking coal.

The position of this field, well to the northeast of the Pittsburgh, Ohio and West Virginia fields, is very advantageous for serving New York City and State and the New England States, and it is to this market that this coal mainly goes.

In addition to the coal, deposits of clay, shale, sandstone, and limestone, and some natural gas occur in this quadrangle. Clay and shale have been developed, on a small scale only, at Punxsutawney and elsewhere. Sandstone for building and concrete has been quarried at McGees, and a little at other points, and a small quantity of limestone has been dug near Richmond and elsewhere. Although no deposits of these materials of great promise were found, enough was seen to suggest a possibility of a greatly increased production in all the lines. Flint fire clay of poor quality was found at a number of places; its presence and abundance suggest the possibility of valuable commercial deposits. Gas has been found in small quantity south of Punxsutawney.

The area is well supplied with railroads. The main line of the Buffalo, Rochester & Pittsburgh Railroad crosses the northwest part of the quadrangle, and its Indiana branch, leaving the main line at Williams, follows the west side of the quadrangle to Richmond. The Pennsylvania & Northwestern Division of the Pennsylvania Railroad enters the quadrangle near McGees Mills and crosses to the northwest corner, where it taps the Punxsutawney-Reynoldsville coal field. It also sends a branch southwestward from McGees Mills up Susquehanna River and Cush Creek, well into the Glen Campbell field. The Pennsylvania Division of the New York Central Lines crosses the southeast corner of the quadrangle, following Susquehanna River, with a branch up Cush Creek, and a detached branch running from Rossiter Junction to Rossiter. Lumber roads extend from Gipsy in the Glen Campbell field, over into the valley of Mahoning Creek.

The Buffalo & Susquehanna Railroad has completed a branch, starting from Juneau and running westward to the Plum Creek mines.

Previous geologic work.

Probably one of the first notices of the geology of this immediate region appeared in Featherstonehaugh's monthly American Journal of Geology and Natural History for April, 1832, in an article on a "Section of the Allegheny Mountains and the Moshannon Valley in Centre County, Pennsylvania," by R. C. Taylor. During the first official geological survey of Pennsylvania, under H. D. Rogers, this region was reached by M. H. Boye, who examined the third and fourth bituminous basins south of Mahoning Creek in 1841, and during the same year J. P. Lesley made a topographic and geologic reconnaissance from the northeast down as far as Punxsutawney. In Rogers' final report, published in 1858, references to this area appear in book IX, division II, subdivision 1, chapters III and IV, and subdivision 3, chapters IX, X, XX, and XXI.

On the organization of the Second Geological Survey of Pennsylvania, in 1874, one of the limited number of districts to be surveyed that first year was the bituminous coal region of Clearfield and Jefferson counties. The work was in charge of Franklin Platt, assisted by R. H. Sanders, H. J. Fagen, and C. A. Young. July and August were spent in Clearfield and Centre counties, and September and October in Jefferson and Clarion counties. In accordance with the plan of work adopted by the Second Survey a stadia line was run by the aids, while Mr. Platt devoted himself to the geology, mines, etc. From the large area covered it is evident that the work could be little better than a reconnaissance, and while a great number of facts were recorded, naturally many mistakes of correlation were made.

For this reason in 1880 W. G. Platt made a detailed survey of Jefferson County, and in 1883, H. M. Chance revised the geology of Clearfield County. These three reports were designated H, H^6, and H^7, respectively. Indiana County was surveyed in 1878 by W. G. Platt, and the report is contained in volume H^4 of the Second Geological Survey. At the time of these surveys there were no railroads in the area of this quadrangle, and as a consequence no commercial mines, nor had any diamond or churn drill holes been made. Outside of the areas at present being developed the conditions as regards information about the geology were, in the time of the Second Survey, much as they are today.

The reports of the Second Geological Survey were accompanied by maps, showing on a scale of 2 miles—1 inch the area of outcrop of the different formations. Comparing these with recent maps, it would appear that the Upper Freeport coal, the top of which marks the bottom of the Conemaugh group, has a considerably greater extent than was then believed. Again, in the valleys of the West Branch of Susquehanna River what was then mapped as Pottsville sandstone proves to be the upper division of the Mahoning sandstone. A minute search failed to find the red Mauch Chunk shale reported as outcropping on Little Creek above Richmond. The correlation of the coals, as given in this report, differs in many points from that formerly given. In calling attention to these revisions no criticism of earlier work is intended. On the contrary, in many ways our own conclusions during the first field season were closely in accord with the earlier results, and it was only after discrepancies had developed in plotting the results in the office, and the matter had been reviewed with great care in the field, that our final conclusions were reached.

Recent work.

The present report and map are the result of a cooperative agreement between the Director of the U. S. Geological Survey and the Topographic and Geologic Survey Commission of Pennsylvania. The U. S. Geological Survey did the work and both organizations shared equally in the cost. The field work for this report was done by Frederick B. Peck and the writer, assisted by E. F. Lines, all of the U. S. Geological Survey, in August and September, 1905. As the office work appeared to indicate that field correlations of the coal beds and rocks were not entirely in accord, additional field work was done by the writer in September, 1906, and August, 1907. The trouble appears to have been due to the assumption, in common with all the earlier geologists, that two massive sandstones occurring apparently above and below the coal-bearing formation, were the Mahoning and Homewood sandstones, respectively. Further work has convinced the writer

that the base of the upper sandstone is about 70 feet above the Upper Freeport coal, and that the coal at its base is the Mahoning coal, and not the Upper Freeport, and that the lower sandstone is of Clarion age.

A glance at the map shows at once where data with reference to coal were abundant and where scarce, except for the drillings, which as a rule were confined to the immediate vicinity of the mining regions. As a whole the geologic and surface conditions in this quadrangle are fairly favorable for determining the geologic structure, but much less so for determining the stratigraphy and coal resources. Aside from the railroad cuts there are hardly any bold exposures of the rocks either in cliffs or steep hillsides. The uplands are gently rolling, and though often strewn with weathered fragments of sandstone, seldom give exposures of the rock in place. Most hill slopes are rather heavily mantled with soil or weathered talus, and most stream valleys are deeply buried in debris that has worked down the hill slopes into them. In a few areas, sandstones which may not actually show in place may yet so weather out as to leave large fragments or blocks on the surface, and by following the upper limit of these fragments around the slope or along the crests of the hills, the approximate position of the sandstone may be judged with considerable accuracy. It thus happens that no small part of the structure of the quadrangle has been worked out by following the outcrops of sandstones which in most areas were seen in place but seldom, and in some areas not at all. In addition to structural work done by tracing sandstone fragments, a large amount of data was obtained by observing the exposures of weathered rock in the roadside drains. These usually are meager and consist of coal blooms, clay streaks, flint clay fragments, and rounded limestone bowlders. Over a large part of the quadrangle the two sources of information just given are practically the only ones available.

Information on the coal was obtained from the coal outcrops or "blooms," from coal prospects or country banks, and from mines and drill holes. As shown by the map, these data are abundant in the limited areas north of Punxsutawney, south and east of Rossiter, between Urey and East Run, and in the Glen Campbell field. It will be noted, however, that nearly all of the mine and other openings are upon the upper, or Freeport, coals, and it is also true that most of the drilling has been done for the purpose of determining the workability of the coal beds already being mined or which it was proposed to mine, so that relatively few of the drill holes have gone below the Lower Freeport coal. This fact, together with the further fact that the lower coals are below drainage in much the larger part of the quadrangle, has rendered knowledge of their character and economic

value very scanty. In parts of the quadrangle the individual coals are quite persistent, holding their thickness and details of section over many square miles. This is true of the Upper Freeport coal from East Run to Glen Campbell and in the Rossiter field, and of the Lower Freeport coal in the field north of Punxsutawney. In the last named area the Upper Freeport coal is extremely variable, ranging from 4 feet to 0, with great irregularity, and the same is true of Lower Freeport coal in the two fields previously mentioned, where that bed ranges from 16 feet down to 0. Apparently similar conditions of variability and irregularity exist in the undeveloped parts of the area, rendering it very difficult to correlate the coal beds. Outside of the fields under actual development, the determination of the structure and correlation of the different members has depended almost entirely on the tracing of sandstone debris and the identification of the sections exposed in the roads, and is therefore given with less confidence than might be desired.

SURFACE RELIEF AND DRAINAGE.

Contour lines.

An examination of the topographic map (Plate I) shows a close series of brown lines covering all parts except small areas along the streams. As the meaning of these lines may be unfamiliar to those not accustomed to such maps, a word of explanation may not be out of place.

It will be noted that the lines in general are somewhat parallel, and every fifth line is heavier than the others. The brown contour lines, as they are called are intended to show the position of lines of equal elevation above sea level; for example, if the ocean were to rise 1500 feet higher than its prsent level it would fill up all of the lower valleys as far as the heavy brown line marked 1500. Were it to rise another hundred feet it would extend up to the line marked 1600, and so on. Where the lines are close together they show the slope to be steep, and where they are far apart they show the slope to be gentle. In general it may be assumed that the slope is uniform between any two of these lines. It will be noted there is one line for each 20 feet of elevation. Every fifth line representing the 100-foot contours, is emphasized by being made heavier. This method of representing the surface configuration of the ground is not as pictorial as some other methods, but it has the great advantage of representing the surface with more or less nearly mathematical accuracy. In other words, if a house, or a mine, or other object, lies between contour lines 1800 and 1820 it is assumed that its elevation above sea-level is between 1800 and 1820 feet, and in general it may be assumed that its elevation is nearer one or the other of those figures in proportion as it is nearer one or the other of the lines. In this way it is possible from

the map to estimate the elevation of any point within perhaps 5 or 10 feet, and thus compare the elevation of any number of points.

Drainage.

The drainage of a region of this character has a special economic bearing in that the railroads follow the streams. The divide between the drainage flowing to the Atlantic Ocean and that going westward to Mississippi River crosses this quadrangle from the middle of the south edge to a point a little south of the northeast corner. It passes through Hillsdale, thence west of Wilgus and Gipsy to Smithport, northward to Johnsonburg, past North Summit Station on the Pennsylvania and Northwestern Division of the Pennsylvania Railroad, west of Newtonburg, and northeastward to the eastern edge of the map. To the east of that line all the streams are tributary to the West Branch of Susquehanna River. This river gives the railroads a low grade to the east. The crooked course of the river increases greatly the length of haul. West of the divide described, all the drainage flows to Allegheny River by way of Mahoning and Little Mahoning Creek. The divide between the two creeks is an irregular east and west line across the middle of the western half of the quadrangle. The two Mahoning creeks and the West Branch of Susquehanna River have bottom-lands suitable for town sites and mining plants.

Altitude of region.

This area is in the Allegheny Mountain region, though in itself it would hardly pass as mountainous. The land lies between 1200 feet and 2250 feet above sea-level. The West Branch of the Susquehanna has an elevation of 1300 feet at the eastern edge and about 1350 at the south edge of the quadrangle. Mahoning Creek has an elevation of 1300 feet where it enters on the north side of the quadrangle. Little Mahoning Creek has an elevation of 1250 feet at Savan, and 1530 near Deckers Point. The main divide ranges in elevation from about 1740 at Hillsdale to 2250 north of Newtonburg. The other divides have intermediate elevations. South of Richmond, Kinter Hill rises to an elevation of 2068 feet.

General character of surface.

In general the surface of the quadrangle is hilly, the valley bottoms being 200 to 700 feet below the adjoining uplands. Where the rocks are shale or shaly the divides are lower, 200 to 400 feet above drainage, and the valley sides are of moderate slope and commonly capable of being cultivated or used for pasturage. Where the resistant sand-

stones outcrop, the valleys as a rule are narrow, with steep sides 400 to 700 feet high, covered with timber and sandstone blocks. The divides that are closely underlain by sandstone are commonly flat-topped and broad-shouldered.

ROCKS.

General statement.

The hard rocks of this quadrangle consist of shale, sandstone, conglomerate or "pudding stones," coal, clay, and limestone. Thin beds of iron ore are found locally. All the rocks in this quadrangle were laid down as sediments in water, except possibly the coal, which probably accumulated in swamp. They all occur in beds which originally lay more or less nearly horizontal, but which have since then been raised into broad folds, so that a rock at one point may be several hundred feet higher than the same bed of rock a few miles distant. The rocks exposed at the surface have a thickness of 950 feet. In addition, some 2,000 feet of the underlying rocks have been pierced by the drill in search of oil and gas. All the rocks exposed belong in the Carboniferous or "age of coal," and all belong in what is known as the Pennsylvanian system of rocks, or "Coal Measures," as it was formerly called. In considering the succession of rocks it will be convenient to describe first the rocks that outcrop, and then those that are wholly below the surface and known here only from drill records.

General character of outcrops.

Taken as a whole, the rocks of the quadrangle are very poorly exposed, and they have all the variations characteristic of coal measure rocks in general. Sandstones which at one point are resistant, massive, coarse-grained, and even conglomeritic, may be fine-grained and shaly a quarter or a half of a mile away, or may grade into shale a little farther on. One of the chief difficulties in deciphering the geology of this area, as compared with many others, is the lack of any rock horizon having distinguishing characteristics which can be traced with certainty over a large part of the area. A rock which can be so traced and used to measure other rocks is called a key rock. The Vanport limestone, which is of the highest value as a key rock in many areas to the west and northwest, has been found in this quadrangle at one point only, just within the edge of the quadrangle west of Richmond. No one of the coal beds is sufficiently persistent to serve as a key over the whole quadrangle. The Upper Freeport coal, which is highly persistent in the Glen Campbell and Rossiter regions, is extremely variable north of Punxsutawney, and the Lower

Freeport coal, which is there very persistent, is thin and irregular in most other parts of the quadrangle. The ridge running from Canoe Creek past Winslow and Newtonburg to the northeast contains the outcrop of a massive sandstone that, within that limited area, is one of the best horizon markers to be found anywhere within the quadrangle. For these reasons the succession and lay of the rocks in some parts of the quadrangle cannot be determined with the same degree of reliance as in other parts. This is particularly true of the southeast corner, south of Burnside and Arcadia, and to a less extent of the southwest corner around Deckers Point; also of the area immediately south of Punxsutawney and west of Canoe Creek. In the northeast corner, in the region drained by the East Branch of Mahoning Creek, sandstone debris is so abundant in the deeply cut valleys that there are few exposures of rock in place. Little reliance therefore can be put on the structure being correct within fifty feet. In general, however, it is believed that the succession of the rocks has been determined correctly and that the elevation of the Upper Freeport coal above sea-level is correct within 50 feet, and over most of the quadrangle probably within 25 feet.

Rocks outcropping.

In geological reports it is customary to name each bed of rock from some place—town, river, hill, etc.—where that rock is typically exposed, as the Pittsburgh coal, the Mauch Chunk shale, the Bellefonte limestone, etc. Where, as in most of the coal fields, the individual beds of rock are usually quite thin, and change in character from place to place, it has been found necessary to divide the rocks into convenient assemblages of strata which are called series, groups, and formations. Thus in this area an assemblage of rocks some 300 feet in total thickness that contains the principal coal beds has been called the Allegheny group (or, by the U. S. Geological Survey, the Allegheny formation) because it is well exposed along Allegheny River. Within this group the various beds of rock and coal are given individual names, such as the Upper Freeport coal (named from the occurrence at Freeport), the Vanport limestone (named from the quarry at Vanport, in Beaver County), etc. In the early days the Allegheny group was often called the "Lower Productive Measures" because of the workable coal beds it contained and in contradistinction from the "Upper Productive Measures" in the western part of the State that contained the Pittsburgh coal.

Above the Allegheny group is the Conemaugh group, named from Conemaugh River. The propriety of calling the Conemaugh a "group" rather than a formation is apparent when it is recalled that the Conemaugh group where fully developed is about 900 feet thick and

contains not less than 77 named members. The Conemaugh group or "Lower Barren Measures," of which about 450 feet exist in the quadrangle, cover a large share of the quadrangle and form nearly all of the hilltops.

Of the less than 1,000 feet of rocks which outcrop, the lower 200 feet, or the rocks below the Allegheny group, belong in the Pottsville (Upper Kanawha) series. These have a very limited extent in the quadrangle, being confined to a small area near McGees Mills, and a still smaller area on the Little Mahoning Creek east of Richmond, and to three little areas in the northeast corner of the quadrangle. These groups of rocks may be considered from the highest point downward.

The accompanying chart (Plate IV) gives a general idea of the stratigraphy of the area as a whole, and of the several districts into which it has been divided for convenience of detailed description. At the left is shown the subdivision of the column of rocks into groups and formations. Both the type section and the several district sections have been constructed by determining the position of prominent elements of the sections, and then filling in the spaces from the sections obtained in the traverses, with due regard for the data obtained by drilling.

Some idea of the variableness of the rocks and of the difficulty of arriving at an average section may be gained by studying figure 2, which shows the sections obtained by drilling in a small area in this quadrangle.

Here it will be seen that sandstone in one section is replaced by shale in the next, etc. The same irregularity shows on the surface in tracing the rocks from hill to hill. The thick coal at the bottom of the sections, however, is persistent and fairly uniform within the area of these sections. It has the same character over much of the area. Notwithstanding the general variableness of the strata, usually some one layer, as one of the coal beds, can be traced from one hill to the next, and serves to tie two hill sections together. Unfortunately, such local key rocks serve over limited areas only and as these areas are commonly detached from each other, it has been difficult in some instances to determine the position of a local key rock when found. Experience has shown that in this general region the thick coals are the most persistent beds, unless exception be made of the under clays which may be more persistent but, as a rule, can not be so readily distinguished from each other. The limestones are valuable markers, because they occur at a few horizons only, and, though in this region more commonly lacking than present, where found they restrict the vertical position of the rocks where they occur to one of a few limestone horizons.

PLATE IV. Generalized columnar sections for the Punxsutawney quadrangle.

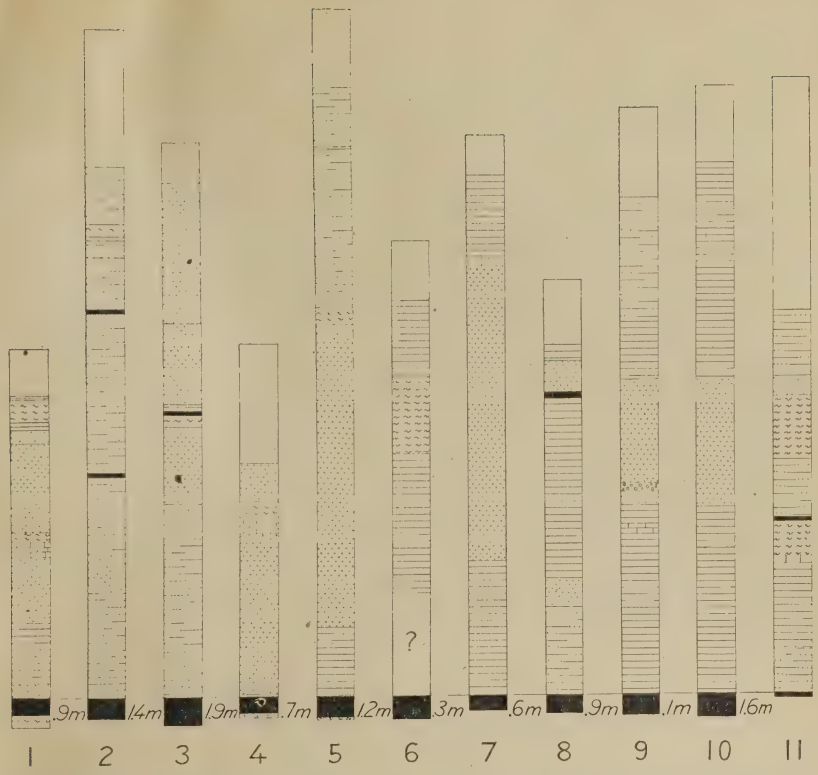


FIGURE 2. Sections through the lower part of the Conemaugh group to show the variable thickness and extent of the rocks. The figures between the sections give the distance between the drill holes in miles and tenths of a mile.

In preparing the type section and the district sections every observed limestone outcrop was noted, with its apparent distance above or below the Upper Freeport coal. It was soon obvious that the limestones above the Upper Freeport coal fall at four horizons approximately 60, 120, 225, and 350 feet, respectively, above that coal. At several places red shale occurs close to the limestone 120 and 225 feet above the Upper Freeport coal, and coals occur in each instance close above or below the limestones. These four limestones are assumed to be at the horizons of the Mahoning, Brush Creek, Cambridge, and Ewing or Ames limestones, respectively, and the accompanying coals were treated as the possible equivalents of the Mahoning, Brush Creek, Bakerstown, and Harlem of other parts of the State. Another coal still higher was considered a possible equivalent of the Little Clarksburg coal. Then all the prominent sandstones above the Upper Freeport coal were plotted and the vertical distance from the top (massive portion) down to the Upper Freeport coal was noted. Most of the sandstones that weather in large blocks or that have been quar-

ried, were found to have their tops about 100, 190, and 300 feet above the Upper Freeport. All of these sandstones were found to be lenses of limited extent, but they were classed as approximating the positions of the Upper Mahoning, the Buffalo, and the Saltsburg sandstones. A still higher sandstone was correlated with the Morgantown sandstone. It should be distinctly understood that no claim is made that these sandstones are parts of the same beds to which those names were originally applied or that they occur at exactly the same horizons. The rest of each section was then plotted as shale on the definite basis of the road sections. Thus, although sandstone occurs in places immediately above the Upper Freeport coal, both road sections and records of drill holes show a preponderance of shale between the Mahoning limestone and the Upper Freeport coal. Above the Upper Mahoning sandstone is the thick body of shale found prominently exposed in railroad cuts around Punxsutawney, Lindsey, and Locust Lane, and equally prominent in many of the road sections. It is undoubtedly true that every foot of the section above the Upper Freeport coal is locally occupied by sandstone and elsewhere by shale, and the interval from the Upper Freeport coal up to the several limestones, coals, and clays varies considerably. The attempt to represent all this would result in valueless jumble. The section given is therefore a type section which, it is believed, will more nearly describe the section at any part of the quadrangle than other sections that might be drawn. The same general principal has been used in drawing the district sections, except that the data used have been restricted to the district.

CONEMAUGH GROUP.

The Conemaugh group takes its name from its exposure in the valley of Conemaugh River. It extends upward from the top of the Upper Freeport coal to the base of the Pittsburgh coal. In the Pittsburgh area the group has a thickness of about 600 feet. To the eastward the thickness increases and may have been originally 700 feet or more in this area. At the present time the greatest thickness left uneroded in this quadrangle is about 450 feet. From that figure the thickness decreases to a feather edge at the outcrop of the Upper Freeport coal. For convenience of detailed descriptions the part of the group found in this quadrangle has been divided into four formations, each of which contains, at least locally, a resistant sandstone and a coal bed at the top, and one or more beds of limestone. The four coal beds are at such intervals above the Upper Freeport coal that they may be equivalent to the Brush Creek, Bakerstown, Barton, and Little Clarksburg coal beds. The limestones seem to be at the horizons of the Mahoning, Brush Creek, Cambridge, and Ames limestones.

The sandstones appear to be only local lenses, but if the naming of the coal beds be approximately correct, then the sandstones are at the positions within which, in other regions of the State, occur the Upper Mahoning, Buffalo, Saltsburg, and Morgantown sandstones. For that reason these names are given to the formations in which these sandstones occur.

As previously stated, and as shown by the section in figure 2, the rocks of this group are extremely variable. The shales, which predominate slightly, are all sandy, many of them so sandy that it is a matter of judgment whether they be called sandy shales or shaly sandstones. The shales are commonly characterized by a light olive green color seldom found in the underlying Allegheny group. The sandstones range from soft, greenish, and shaly through thick-bedded, hard, resistant, and coarse-grained to conglomeritic and cross-bedded. The general section, as worked out and described in a preceding paragraph, indicates a sort of rhythm in the deposits of this group, each formation beginning with shale deposited in deep quiet water, followed by sandstone, laid down in strong currents, and that by limestone, clay, and coal. The vegetation from which the coal was derived probably accumulated on land. Whether the sandstones were laid down on an irregularly eroded surface, as generally elsewhere, is uncertain here for lack of exposures.

Morgantown formation.

The Morgantown formation, so far as seen, is composed of shale below thin-bedded sandstone, with one or more coal beds, none more than a few inches thick. One of these beds may represent the Little Clarksburg coal. The formation is confined to a few hilltops in the Punxsutawney and Brush Valley synclines.

Saltsburg formation.

In general, the lower part of this formation consists of shale which is to be seen in many areas just above the Bakerstown coal. At the top of this shale are locally red shale, clay, and coal. The lower coal, correlated as the Bakerstown, was noticed in a few places only, as in the tops of the hills in the northeast corner of Morgantown Township. This position appeared to be about 225 feet above the Upper Freeport coal. The upper coal bed outcrops in many places on the hills south of Punxsutawney and between Cush Creek and Susquehanna River. Where seen this bed is less than one foot thick but it has been mined half a mile south of Bowdertown. It lies about 315 feet above the Upper Freeport coal. The limestone associated with this coal is found in Henderson and northern Bell townships of

Jefferson County, where it has been quarried a little for burning. The relation of the coal and limestone and the character of the limestone may be seen at the W. P. Pifer quarry (E a 1 on Plate III) where the section is as follows:

Section of limestone at the W. P. Pifer quarry.

	Ft.	in.
Soil		
Coal		
Clay	1	
Clay, brownish	3	
Limestone		8
Limestone and clay	1	6
Limestone, dense, compact, bluish-gray	2	6
Clay		
Total limestone	4	8

The correlation of this coal and limestone is not known, but the limestone is about in the general position of the Ames limestone, though it does not have the dark-bluish or greenish-gray color, nor the granular surface due to crinoid stems, that are characteristic of the typical Ames of western Pennsylvania. The coal above may be at the horizon of the Barton coal of Somerset County, or the coal and limestone may have the position of an unnamed coal and limestone in the Pittsburgh region, given in a section by I. C. White[1].

Associated with this limestone in places is a distinct band of red shale which, it is thought, may represent the "Pittsburgh reds" of western Pennsylvania and West Virginia. A few feet below this coal in Morgantown Township is a resistant sandstone that caps many of the hills and has a marked effect on the topography, producing flat-topped hills and broad, shallow, rock-floored valleys. The sandstone is not common in other parts of the quadrangle. This sandstone in its relations to other rocks has about the position of the Saltsburg sandstone of Indiana and Westmoreland counties.

Buffalo formation.

The Buffalo formation includes the strata between the coal horizons about 120 and 225 feet above the Upper Freeport coal. The lower coal is thought to have the position of the Brush Creek or Gallitzin, and the upper coal to have the position of the Bakerstown coal of

[1] White, I. C., U. S. Geol. Survey Bull. 65, p. 72, 1891.

Allegheny County. The Bakerstown coal is more than 2 feet thick locally and has been mined in a few places. According to the drill records, however, the coal cannot be assumed to have any commercial value. A little below the Bakerstown coal, red shales and weathered limestone fragments are found locally, as notably in the areas west of Canoe Creek. These red shales may represent the "lower reds" and the limestone, the Cambridge limestone, of western Pennsylvania. At several places in the western part of the quadrangle coarse-grained or gritty sandstone was found, the top of which is about 190 feet above the Upper Freeport coal. Among the occurrences of this sandstone may be mentioned the hills southwest of Rossiter, northwest of Juneau, southwest of Savan (outside the area mapped), and on Cold Spring Run, northwest of Punxsutawney. This sandstone is within the interval in which occurs the Buffalo sandstone of Armstrong County. Below it is a thick body of shale, prominently exposed in the railroad cuts around Punxsutawney, at Lindsey, and north of Locust Lane.

Mahoning formation

The Mahoning formation includes the strata from the top of the Upper Freeport coal to the top of the coal 120 feet higher. Near the middle of the formation occurs a little black shale or thin coal, underlain by a bed of clay, and, at least locally, by limestone. A section of the strata in this horizon was exposed in making a cut for the Buffalo, Rochester & Pittsburgh Railroad at Williams station, east of Punxsutawney. The section is as follows:

Section at Williams station, Buffalo, Rochester & Pittsburgh R. R., 2½ miles east of Punxsutawney.

	Ft.	in.
Sandstone, brown, shaly	6	
Shale, light-drab		6
Shale, black (place of Mahoning coal)		1
Clay, olive drab	2	
Shale, deep chocolate and olive (fairly typical red shale)	4	
Limestone, highly ferruginous (much of it calcareous iron ore) ("Johnstown ore" horizon)	4	
Shale, olive, very fine-grained	23	
Shale, black		1
Clay, olive-drab, hard		6
Clay, dark-drab		10
Clay, olive-drab	2	
Shale, olive sandy, grading into olive sandstone below, to railroad track	10	
	53	

The black shale or coal, clay, and limestone in this horizon have at times been mistaken for the Upper Freeport coal, which lies 70 feet lower. The main reason for this mistake has been the presence of a massive sandstone above this coal and a thick body of shales below, which are features common to the Upper Freeport coal horizon. The sandstone over this coal, which is correlated as the Mahoning coal, is well developed as a massive coarse-grained rock in the divides south of Mahoning Creek, and east of Punxsutawney. It also caps the ridges north and west of Newtonburg. The shales below the Mahoning coal are exposed in the railroad cut at Williams station and in many of the road sections. A trace of red shale is found in places, associated with the Mahoning limestone. In many places parts of the shale below the Mahoning coal have somewhat the character of flint clay.

ALLEGHENY GROUP.

The Allegheny group is the coal-bearing group of this area. The number of coal beds or coal-bearing horizons increases from about 5 on the western edge of the State to 10 or 12 on the eastern edge of the coal field. Seven horizons appear to carry coal widely and each has been named from some locality where the coal is prominent. In the Clearfield area, of which this field is generally considered to be a westward extension, the coals have long been designated by letters. The names of the seven coal beds or horizons and the corresponding letters are as follows:

E or Upper Freeport
D or Lower Freeport
C′ or Upper Kittanning
C or Middle Kittanning
B or Lower Kittanning
A′ or Clarion
A or Brookville

The coal beds in this group are variable in thickness and character. In places all are thick enough to work, while elsewhere not more than one or two are of workable thickness. In some areas single beds maintain a uniform thickness and section for many square miles. In other areas the same beds will vary from 3 or 4 feet to zero within short distances, and without any apparent regularity. On account of their value the coals are discussed more at length elsewhere. Each coal bed usually lies on clay and is covered by shale, though in places sandstone forms the roof.

Distance between coal beds.

The distances between the beds are shown in the following table:

Distance between coal beds of Allegheny group in Punxsutawney quadrangle, in feet.

	Northeast corner	Glen Campbell	Southeast corner	Rossiter	Northeast corner
E to D	40	35	30	40	40
D to C′	70	40	55	35	....
C′ to C	55	55	50	80	100
C to B	40	60	60	55	65
Total E to B	205	190	195	210	205
B to A	95	70	....	....	....

The interval from the E coal to the B coal is remarkably regular in this region, as it is in adjoining regions, averaging about 200 feet. The interval from the E coal to the D coal, though ranging from below 30 feet to above 40 feet, is established by many measurements. Between the D and B coals are from two to four coals, and as the measurements below the D coal are relatively few in number, it is quite possible that some of the figures given in the table above are between coals at different horizons in different parts of the field. Of the coals between the E and B, the D is a valuable bed but stratigraphically irregular. In central Clearfield County it splits and the two parts are as much as 55 feet apart. In the Glen Campbell region it appears to be a double or triple bed. South of this area there appear to be two overlapping beds in about this position. Probably this bed is a double one that is locally united into one bed, locally separated into two distinct beds and locally one or the other of the beds is lacking.

Below the B coal are about 100 feet of rocks containing the Clarion sandstone and coal and in the region to the west of this the Vanport limestone.

For the purposes of mapping and detailed description the Allegheny group has been divided into three formations: the Freeport, extending from the top of the Upper Freeport coal to the top of the Upper Kittanning coal; the Kittanning, extending from the top of the Upper Kittanning coal to the base of the clay under the Lower Kittanning coal, and the Clarion, extending from the base of the Kittanning formation to the base of the group. The Freeport and Kittanning formations are each divided into two parts, the line between the two parts of the Freeport member being drawn at the top of the Lower Freeport coal, and that between the two parts of the Kittanning member being drawn at the top of the Middle Kittanning coal.

Freeport formation.

Beginning at the top, the Freeport formation contains the Upper Freeport coal described beyond; then the underclay of the coal, commonly from 2 to 9 feet thick, generally of good quality; then the Upper Freeport limestone; sometimes a little flint clay which comes at the horizon of the Bolivar clay; then shale or sandstone to the D bed. Records of drill holes indicate that in places the limestone is from 5 to 20 feet thick. On the surface, as a rule, only weathered fragments of the limestone are seen. The rocks below the E bed are exposed in the railroad cuts along Canoe Creek south of Cloe post office, and consist mainly of sandy shale or shaly sandstone.

No clear-cut sections of the rocks between the D and B coals were seen in this quadrangle. The sections given in Plate IV represent the sequence as best it can be determined.

The D bed is described in detail beyond. The clay under it is thinner as a rule than that under the E coal. The Lower Freeport limestone is absent over most, if not all, of the quadrangle. The rocks between the D and C coals are commonly concealed. A fairly resistant sandstone below the D coal underlies many of the ridge tops in the central part of the quadrangle. Locally this sandstone is coarse-grained or even conglomeritic, as northeast of Urey.

Kittanning formation.

As far as seen, the rocks of the Kittanning formation are sandy shales and shaly sandstones. The C′ and C coals are commonly too thin to work in this area, but locally they reach a workable thickness, and at one point the C′ bed contains a thick bench of cannel coal. The rocks of the Kittanning formation were nowhere clearly seen, though parts of the section are exposed in railroad cuts south and east of McGees. In that area the Upper Kittanning member appears to be predominatingly shaly and the Lower Kittanning member predominatingly sandy. In a cut a short distance south of McGees, the B coal is overlain by about 10 feet of shale that has been crushed, folded and faulted, while unconformably over the shale is 10 feet of sandstone lying flat. This unconformity has been noted over a broad area in Pennsylvania and is the most pronounced feature of the kind in the Alleghey group. See figure 3.

FIGURE 3. Figure showing overthrust of sandstone on shale in railroad cut south of McGees. The coal is the B. The contact of the shales over the B coal with the overhanging sandstone is commonly one of unconformity. The base of the sandstone here is slickened or polished by friction.

Clarion formation.

The Clarion formation is best exposed around McGees and between that place and Mahaffey.

Section of lower part of Allegheny group near McGees.

	Ft.	in.
Sandstone and shale	6	
Shale, drab, fissile	10	
Coal, C, 8 inches to	1	1
Bone and shale	2	
Clay, drab and brown grading into sandstone at bottom	4	6
Sandstone, light brown, thin bedded to irregular bedded	33	6
Coal, B	1	10
Clay, light drab	3	
Flint clay, poor		6
Clay, light drab	4	6
Hidden interval, partly sandstone mostly clay and shale	12	
Clay, light drab	5+	
Iron ore, poor (Buhrstone ore?)	1	
Position of Vanport limestone	0	
Clay shale	5	
Sandstone, shaly, carbonaceous	6	
Sandstone, massive to conglomeritic (Clarion) stringers of coal in base	30	
Shale with iron concretions, 4 feet to		6
Coal A, 16 inches to	4	
Clay, drab, sandy, poor, 4 feet to	8	
Pottsville, light brown and drab sandstone		

From its position between the A and B coals it seems possible that the iron ore in this section may represent the Buhrstone ore that through most of western Pennsylvania lies immediately above the Vanport limestone. In the same way the thin strip of flint clay below the B coal may represent the flint clay that occurs below the Lower Kittanning coal in Clarion County and elsewhere.

The Vanport limestone, which is of economic value and serves as a "key" rock in other areas, in this quadrangle was seen at only one point, west of Richmond. The Clarion sandstone, which is between the B and A coals, is a prominent massive sandstone around McGees and Richmond, the two regions where it outcrops. It is suitable for quarrying over a large area north of McGees.

POTTSVILLE (KANAWHA) SERIES

The Pottsville series is exposed only around McGees and Richmond, and in those places the outcrop is usually hidden by the debris from the massive Clarion sandstone above. It is not pierced by any of the holes drilled for coal, so that little is known of it. Near McGees the following section was made:

Section of top of Pottsville series near McGees.

	Ft.	in.
Base of Allegheny, drab clay		
Sandstone, drab, shaly, laminated to even bedded	10	
Sandstone, irregular bedded to massive	20	
Sandstone, shaly	10	
Clay shale	5	
Coal, Upper Mercer	1	10
Under clay	2	
Sandstone in thin, regular beds	3	
Shale, with lines of sandstone plates		10
Shale, drab	10	
Coal, Lower Mercer	2	
Clay	4	
Connoquenessing sandstone in Bear Creek		

In general the Pottsville series in this area consists of about 200 feet of rocks, composed of more or less massive sandstone at the top, the Homewood; a group of shales, coals and limestones, the Mercer; and a lower sandstone, the Connoquenessing. Farther west the Sharon coal and sandstone come in still lower. In the anthracite field there are many hundred feet of sandstone, shale and coal representing deposition in early Pottsville time, when this area was land and was being eroded.

The Homewood is a prominent, massive sandstone around Curwensville. East of this region and in many other places it is from 30 to 60 feet thick. Here it does not appear to be very massive and prominent, though data on it are very meager.

The Mercer group, so classed because of its thickness of several hundred feet in West Virginia, varies in thickness from a few feet to 20 feet or more. Near McGees it contains two thin coal beds. In Beaver Valley each of these coal beds is usually underlain by limestone. In the eastern part of Clearfield County there is usually only one coal bed and this is sometimes lacking, but under it is locally a thick bed of clay that in places contains a high grade of flint clay.

The Connoquenessing sandstone, commonly shaly or interbedded with shales, is 100 feet or more thick. It barely outcrops in this quadrangle and is nowhere well exposed. Commonly beds of shale, and locally the Quakertown coal, divide it into two or more parts.

The Pottsville is the series that contains the valuable coals of the Kanawha, New River, and Pocahontas fields of West Virginia and all of the coals of Virginia, Tennessee, Georgia and Alabama. It contains the Lykens Valley coals of the anthracite field of Pennsylvania.

MAUCH CHUNK SERIES

The Mauch Chunk series, which in the eastern part of the State has a thickness of several thousand feet, is represented but poorly, or not at all, in the Punxsutawney quadrangle. The Mauch Chunk, as originally laid down, appears to have decreased in thickness from east to west. Following the depositing of the Mauch Chunk, central Pennsylvania was lifted above sea-level, and remained so for most of Pottsville time. During this emergence much or all of the Mauch Chunk in this quadrangle was removed by erosion. North of this region even some of the underlying series was eroded. The Mauch Chunk exposed on the Allegheny Front is red and green shales and sandstones, with some typical drab shales and gray sandstones. Deep-red shale, supposed to be of Mauch Chunk age, occurs on Anderson Creek near Curwensville, to the east of this quadrangle. Rocks of Mauch Chunk age were not seen in this quadrangle and drillers for gas south of Punxsutawney do not report any red shale in the position of the Mauch Chunk, suggesting that it is absent. Mauch Chunk rocks are shown on the geological map of Indiana County prepared by the Second Pennsylvania Survey, but were not found in a careful search during the recent field study. It is probable, therefore, that some of the Mauch Chunk may be present in the southeast part of the quadrangle, but it is absent in the northwest part.

POCONO SERIES

The Pocono series does not outcrop in this quadrangle but it is pierced in the gas wells south of Punxsutawney. In the eastern part of the State it is from 1,000 to 2,100 feet thick: on the Allegheny Front it is 1,100 feet thick, of which the upper 400 feet is massive sandstone, the Burgoon, "Big Injun" of the drillers; the lower 700 feet consists of shales and sandstone, some of the shales being red. On the upper Allegheny River, to the west of this quadrangle the Burgoon (Logan) has a thickness of 250 feet and the lower part

of the series (Cuyahoga group of Ohio,) a thickness of 450 to 500 feet, including the Meadville (shale and limestone) at the top, Sharpsville (sandstone), Sunbury or Orangeville (shale), then the Berea (sandstone) formations. In this quadrangle the Pocono has an intermediate thickness and character somewhat nearer the section on Allegheny River. On the Allegheny Front and in this quadrangle the lower part of the section contains considerable quantities of red shale. On Allegheny River the red shales have largely disappeared.

DEVONIAN SYSTEM

Gas wells south of Punxsutawney pierce about 1500 feet of rocks below the supposed base of the Pocono. These rocks are of Devonian age, and are brought to the surface east of this region by great folds. A fold in Centre County exposes more than 8,000 feet of Devonian rocks. These are predominantly shaly at the base and sandy at the top. In the Punxsutawney area the Devonian rocks probably are thinner and more shaly. Only the upper part of the Devonian has yet been reached by the drill. The uppermost group, the Catskill, has a thickness of 2,000 feet on the Allegheny Front, where it is mostly red shale and sandstone. The group thins northward to 500 or 600 feet in Warren County, and to 200 or 300 feet on the western border of the State. The red color of the shales gives way to green or gray to the north and west. The detailed sections are given in Figure 4.

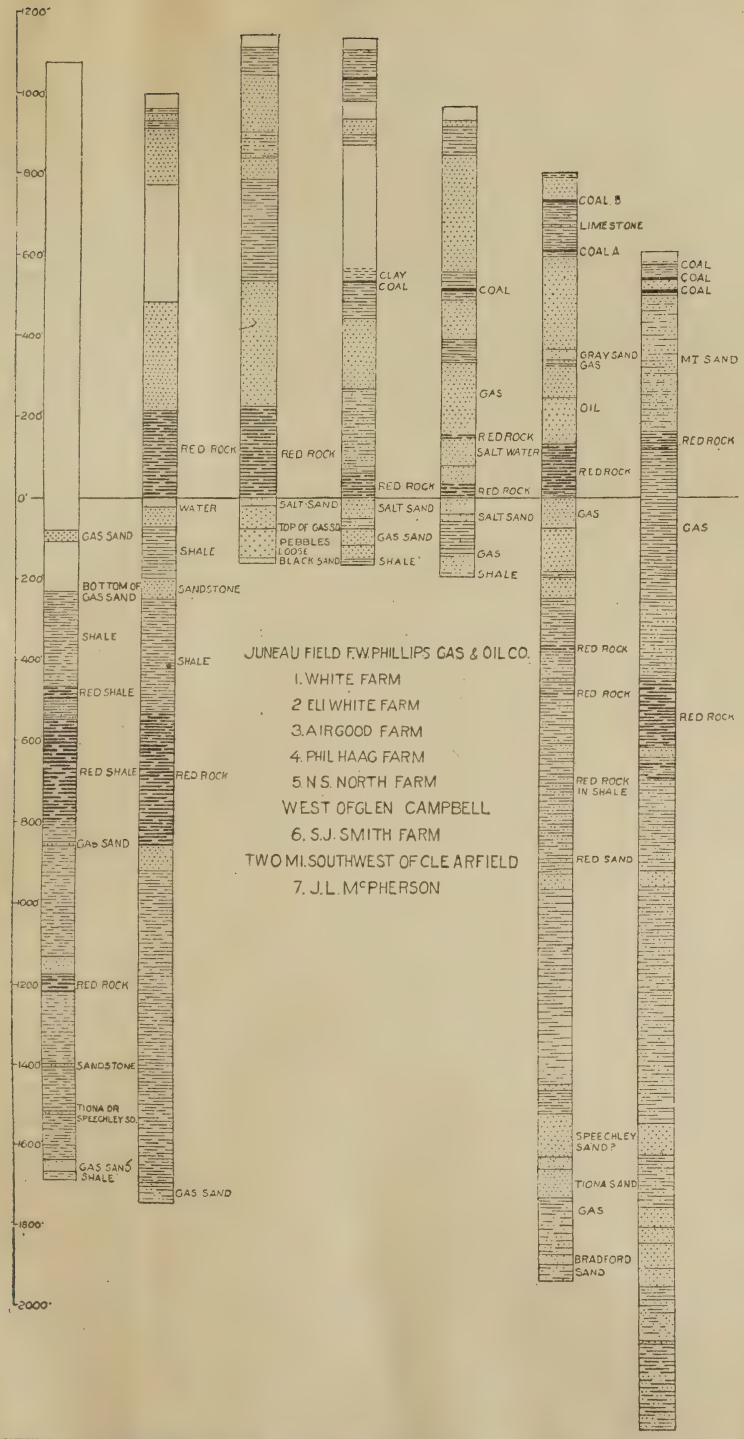


FIGURE 4. Sections of seven deep wells in central Pennsylvania showing character of rocks below the surface.

STRUCTURE.

Meaning of term.

By the structure of the rocks is meant their altitude or position relative to sea level. As is well known the rocks of central Pennsylvania, after being laid down in nearly or quite horizontal beds, were subjected to great pressure, apparently from the southeast, which pushed the rocks into long folds running from northeast to southwest. East of the Allegheny Front the folding is very close and in some areas the folds have been overturned or broken. In this quadrangle, which lies a little west of the Allegheny Front, the folds have the same direction but are broad and low. The inclination or angle by which the bedding planes of the rocks diverge from the horizontal is called the dip. A fold in which the rocks dip away from the axis is called an anticline. Where they dip toward each other to form a trough the fold is called a syncline. The line following the highest part of an anticline and the lowest part of the syncline is known as the axis. These axes are not horizontal, but rise much higher or sink lower in some areas than others. The dip of a rock in one direction only, in a limited area on the flank of a syncline or anticline, is called a monocline; the term monocline may refer to a downward flexure of the rock from one level to another.

Representation of structure.

In this report, as in the similar reports on the geology of western Pennsylvania, the structure is represented by contour lines, similar to those used in representing the elevation of the surface. In this quadrangle contour lines have been drawn 50 feet apart in vertical elevation. A contour line marked 2,000 feet on the map means that some stratum, in this case the top of the E coal bed which forms the top of the Allegheny group, is estimated to be just 2,000 feet above sea level along that line. Near that line is another mark 2,050 feet and the top of the E coal is assumed to rise 50 feet between the positions of the two lines. The structure contour lines are shown on the map in red. By use of these contour lines it is possible to estimate the depth from the surface of any coal bed or other stratum. For example, if it is desired to know how far the B coal is below the surface at a given point, an examination of the map may show that the point in question is at an elevation of 1950 feet. At that point is a structure contour line of 1,600 feet, showing that the top of the Upper Freeport, or E coal, is 350 feet deep at that point. As the stratigraphic section shows the B coal to lie nearly 200 feet below the E, it is approximately 550 feet from the surface at that point to the B coal. If the particular stratum is above the E coal, we should subtract its distance above the E from the depth of the E coal.

Description of structure.

The geologic structure in this quadrangle consists of a broad anticline crossing from south of the northeast corner to west of the center of the south line of the quadrangle and of two prominent synclines, one on either side of the broad anticline. The broad anticline splits near the middle of the quadrangle and one fork passes southwesterly to near the southwest corner of the quadrangle. The principal anticline, which is called the Chestnut Ridge anticline here and farther south, corresponds in position with and makes Chestnut Ridge a prominent ridge in the southern part of the State. The syncline on the north passes through Punxsutawney and is known as the Punxsutawney syncline. The one to the southeast is called the Brush Valley syncline. The western split of the main anticline is called the Kinter Hill anticline, from a hill in the southwest part of this quadrangle through which it passes. The name Richmond, applied to this anticline in the Indiana quadrangle, has been abandoned. Between the two forks of the main anticline is the Dixonville syncline.

Chestnut Ridge anticline.

The axis of the Chestnut Ridge anticline, as shown on the map, extends from some distance south of the northeast corner of the quadrangle southwest through the southeast corner of Jefferson County, then southwest and south past Smithport, west of Gipsy, and through East Run on the south line of the quadrangle. In the central part of the quadrangle the top of the anticline is very broad and the rocks are practically flat for four miles across the crest, the E coal having an elevation of 1,850 to 1,900 feet. To the northeast along the axis of the anticline, the rocks rise and the E coal has an elevation of 2,100 feet over the part of the quadrangle lying in Clearfield County. Southwest from the center of the quadrangle, the rocks along the axis lie nearly flat from Smithport almost to East Run, then dip to the edge of the quadrangle. On either side of the broad top, the rocks dip steeply to the southeast and northwest, in many places 200 feet or more to the mile. The dip appears to be fairly uniform, partly because of lack of exact information.

Kinter Hill anticline.

The Kinter Hill anticline sets off as a spur from the Chestnut Ridge anticline near the center of the quadrangle, crosses Little Mahoning Creek a little above the mouth of Rishell Run, passes southwest through Kinter Hill, and leaves the quadrangle one mile north of the southwest corner. The E coal has an elevation of 1,800 feet where this anticline leaves the main arch, then rises to 1,850 feet

between Doty Roundtop and Kinter Hill, but descends to 1,750 feet at the west edge of the quadrangle. Between that anticline and the Chestnut Ridge anticline is a shallow syncline that follows Little Mahoning Creek and becomes stronger south of this area.

Punxsutawney syncline.

The axis of the Punxsutawney syncline crosses the north edge of the quadrangle near the Eleanora shaft with a direction west of south; then turns south of west through Punxsutawney following down Mahoning Creek Valley. Along the axis of the syncline, which appears to be quiet flat, the E coal has an elevation of less than 1,150 feet above sea level. From that elevation the coal rises sharply to the southeast toward the Chestnut Ridge anticline, and toward the northwest corner of the quadrangle.

There appears to be a broad bench on the slope between the Chestnut Ridge anticline and the Punxsutawney syncline in the region north and west of Juneau. The exact shape of this bench was not clearly determined but is about as shown. The occurrence of a gas pool in that area may be explained by the presence of this bench.

Brush Valley syncline.

The steeply dipping rocks on the east flank of the Chestnut Ridge anticline flatten out toward the southeast part of the quadrangle into a broad, flat-bottomed trough whose axis lies a little south and east of Burnside. From that axis the rocks rise gradually toward the east.

GENERAL ECONOMIC GEOLOGY.

The most important mineral in this field is coal. All of the high grade Allegheny coals are present under a large part of the quadrangle. A large quantity of clay and shale occurs here, some of which may be of considerable value though most of those substances do not appear to be of high grade. Limestone is common in at least one horizon and less common at several others. The limestone will have value for use in agriculture rather than as building stone. Certain areas in the quadrangle show an abundance of sandstone, more suitable for rough structural work than for fine buildings.

Gas has been found south of Punxsutawney, and a little is reported north of Newtonburg. Iron ore occurs in the quadrangle but not enough to be of present value.

COAL

Number and names of beds.

Practically all the available coal of this region is at six horizons in the Allegheny group. These have been correlated with coal horizons in the type section along the Allegheny River and named from the top downward, the Upper Freeport, Lower Freeport, Upper Kittanning, Middle Kittanning, Lower Kittanning, and Brookville. Coals appear in a number of other horizons, especially between the Lower Freeport and Lower Kittanning, and locally between the Lower Kittanning and the Brookville coals. The latter coals may correspond to the Clarion coals farther west. Since the days of the first Pennsylvania Geological Survey it has been customary in this general region to use letters to designate the coals, the Brookville coal being known as the A, the Clarion, if present, as the A′, the Lower Kittanning as the B, and the Middle Kittanning as the C, the Upper Kittanning as the C′, the Lower Freeport as the D, and the Upper Freeport as the E. In some of the earlier reports there was some confusion in the use of these letters, especially as used by different geologists; for example, the first report on this area by the Second Pennsylvania Survey uses the letter D for the Upper Kittanning coal and D′ for the Lower Freeport. In general, however, the letters as given are those in common use today throughout the Clearfield district.

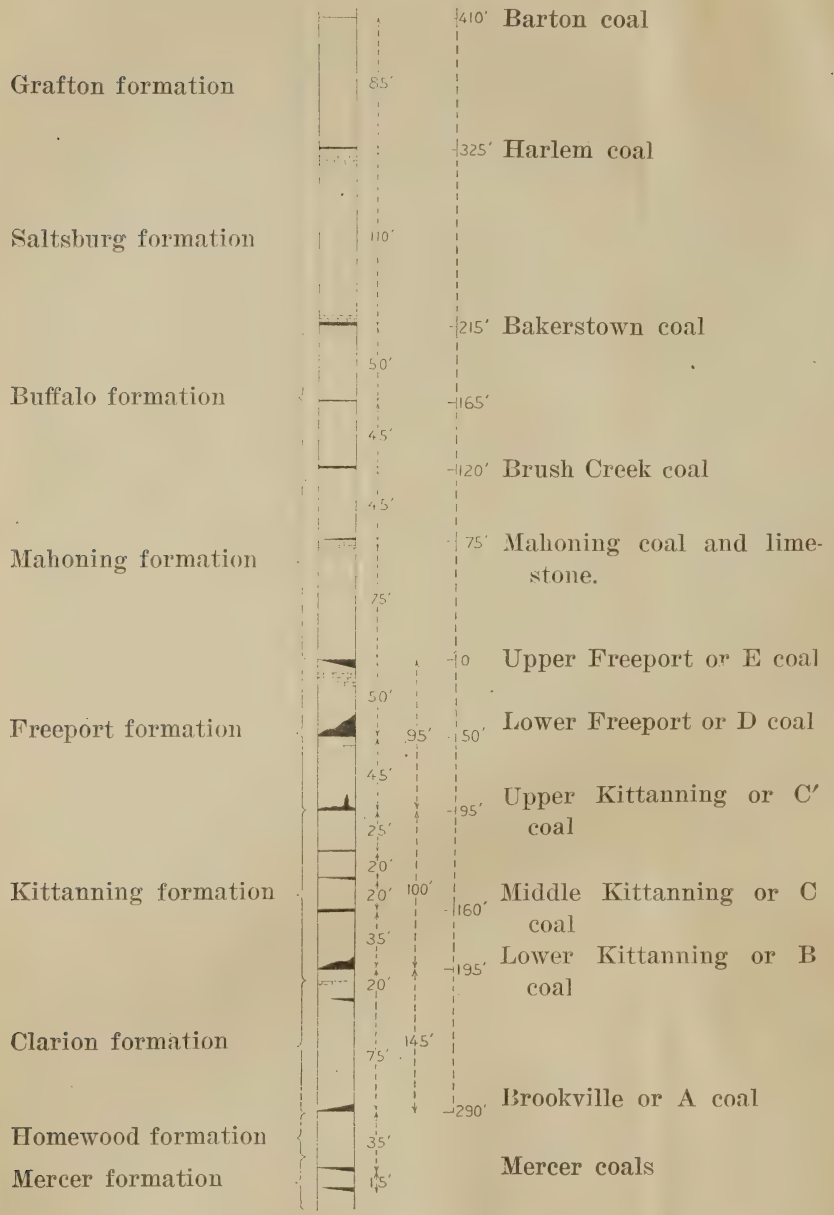


FIGURE 5. Skeleton section of all coal beds in the Punxsutawney quadrangle, showing their relation and thickness.

Figure 5 is a columnar section showing the number of coal beds, their average thickness, their average distance apart, and their relation to certain rocks which may serve in places as "key" rocks.

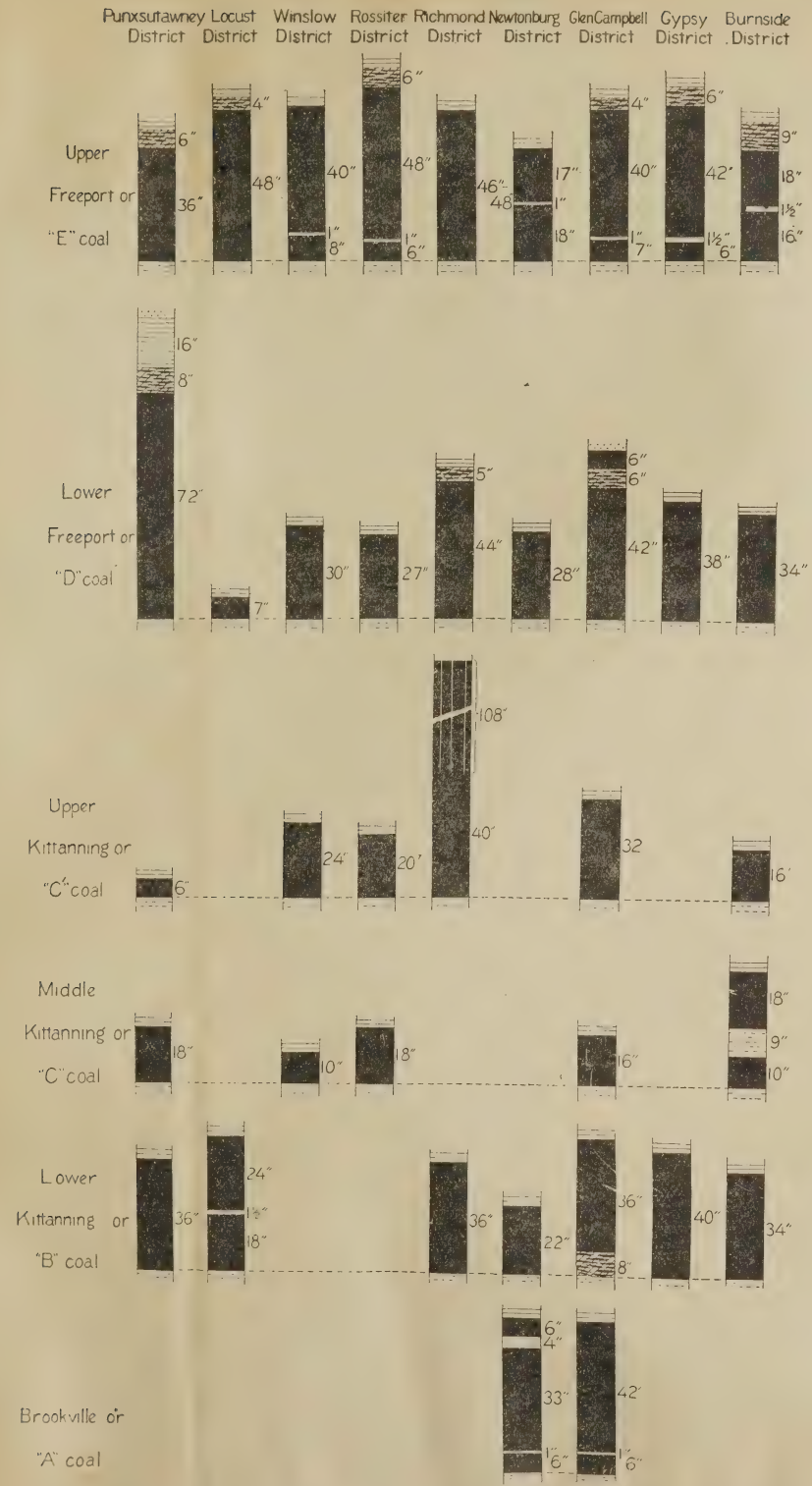


FIGURE 6. Selected sections of the workable coal beds in the several districts of the Punxsutawney quadrangle. These are average sections for the workable areas, not of the districts.

As shown in figure 6, although six coal beds are worked in places, the Upper Freeport, as far as our knowledge goes, is the most valuable bed and is of mineable thickness over most of the quadrangle. The Lower Freeport is variable in thickness but is more than 2 feet thick in much of the quadrangle. The Upper and Middle Kittanning coal beds are usually too thin to work under present conditions. The Lower Kittanning, as far as our limited knowledge goes, appears to be locally, if not generally, over 2 feet thick. The Brookville coal is thick in the very limited area in which it is known. These coals are taken up a little more fully in separate paragraphs, beginning with the Upper Freeport or E coal.

Upper Freeport or E coal.

As shown on Plate V, and by the sections, figures 7 and 8, the Upper Freeport coal is regular in thickness and commonly workable. About half of the sections show a layer of bony coal at the top, ranging from 2 to 12 inches but usually about 6 inches thick. Many of the sections have a streak of shale, clay, or bone from 4 to 12 inches from the base.

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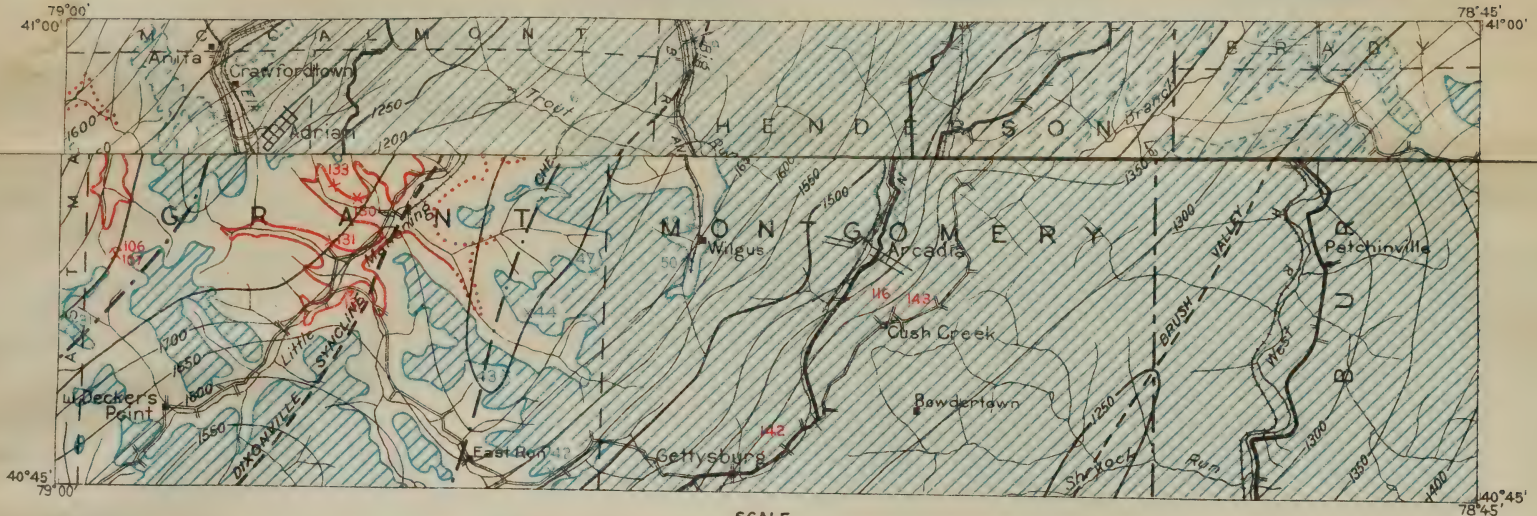
PLATE V.



SCALE

0 1 2 3 4 MILES

Upper Freeport Coal

Coal 2′ or more

Coal, thickness uncertain probably 2′ or more

EXPLANATION

1500 Structure contours on Upper Freeport coal

Coal outcrops

Known to be variable 2′ or more and less than 2′

Commercial mines

Small or abandoned mines

Outcrop of Lower Kittanning coal

Coal, position probably correct 2′ or more (net) thick.

Coal, position in doubt 2′ or more (net) thick.

Coal, position probably correct thickness not known.

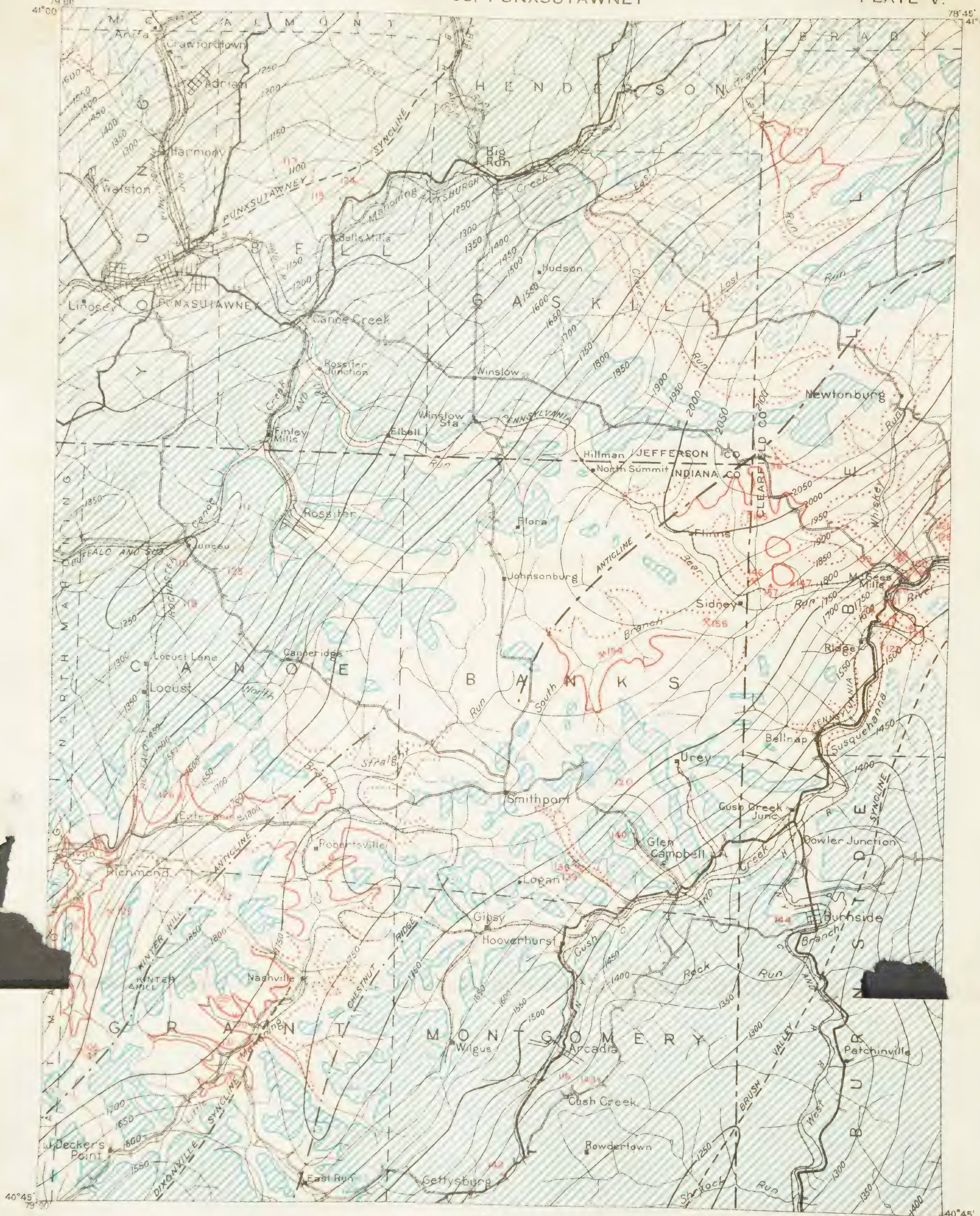
MAP SHOWING THE DISTRIBUTION AND THICKNESS OF THE UPPER FREEPORT OR E COAL AND THE OUTCROP OF THE LOWER KITTANNING OR B COAL IN THE PUNXSUTAWNEY QUADRANGLE.

TOPOGRAPHIC AND GEOLOGIC

ATLAS OF PENNSYLVANIA

SHEET 65. PUNXSUTAWNEY

PLATE V.



SCALE

1 0 1 2 3 4 MILES

EXPLANATION

Upper Freeport Coal

Coal 2' or more

Coal, thickness uncertain probably 2' or more

1500 Structure contours on Upper Freeport coal

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MAP SHOWING THE DISTRIBUTION AND THICKNESS OF THE UPPER FREEPORT OR E COAL AND THE OUTCROP OF THE LOWER KITTANNING OR B COAL IN THE PUNXSUTAWNEY QUADRANGLE.

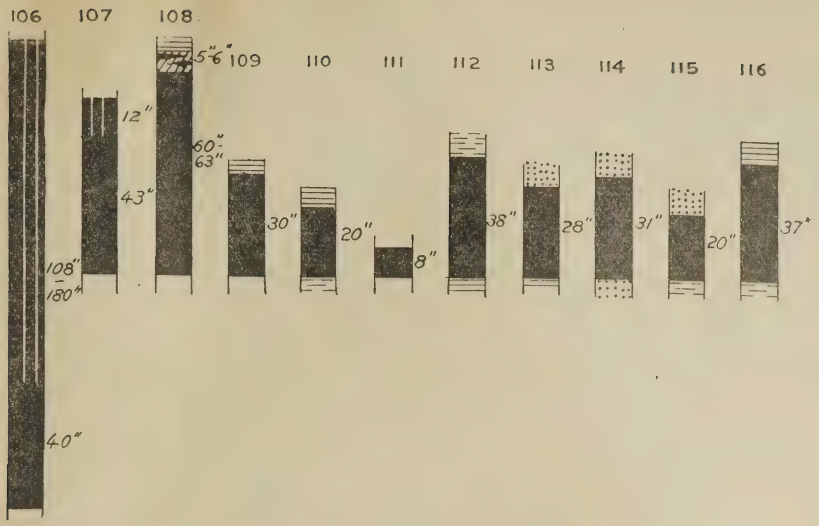

FIGURE 10. Selected sections of the Upper Kittanning or C′ coal. (see note under figure 7). (106) Af2 Altoona mine (maximum 9-15 ft.). (107) Af2 Altoona mine (minimum). (108) Ae6 A. Jeffries mine. (109) Ae5.

Upper Kittanning or C′ coal.

As shown by the sections, the Upper Kittanning coal reaches a workable thickness in spots but is generally too thin to work under present commercial conditions. This bed is characterized in Pennsylvania by tending to carry a certain amount of cannel coal, and one mine exists in this quadrangle where in part of the mine 9 feet of cannel overlay a bench of bituminous coal. Very few openings have been made on this coal, but many of the drillings show it to have a thickness of 2 feet or more, so that it may be assumed that ultimately it will furnish at least a small amount of coal to commerce. South of Richmond is a mine in a five-foot bed of coal that appears to be at this horizon.

Middle Kittanning or C coal.

As shown by the sections, the Middle Kittanning coal is very thin over most of the quadrangle, not being workable under present conditions. The thickness usually ranges from a few inches to 24 inches. The roof is usually shale and the floor clay.

Lower Kittanning or B coal.

The Lower Kittanning coal is exposed over a very small area only, so that our knowledge of it has been derived mainly from the very few wells that have pierced it. Such openings as exist, and the few

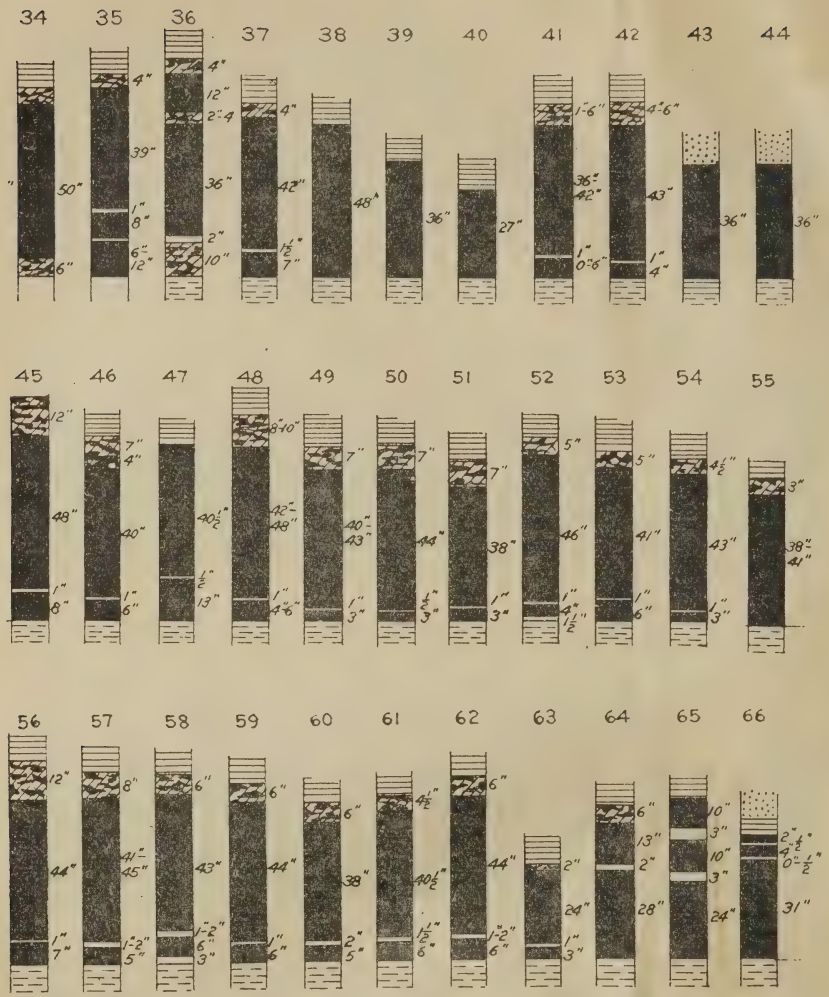

FIGURE 8. Selected sections of Upper Freeport or E coal in the Punxsutawney quadrangle.

(34) Dd15. (35) Dd11 Glenwood No. 11 mine. (36) Dd11 Glenwood No. 11 mine. (37) Dd10 Depp mine. (39) Dd9 Outcrop. (40) De4 Winkey mine. (41) De9 Indiana No. 3 mine. (42) Cf11 Westover and Baker mine. (43) Bf8 J. A. Numann mine. (44) Fb7 Clover Run No. 1 mine. (45) Ce16 Jas. Gorman mine. (46) Ce21 Carnahan mine. (47) Cf3. (48) Ce12 Arcadia No. 44 (No.8) mine. (49) Cf5 Arcadia No. 43 (No.4) mine. (50) Cf6 Indiana No. 5 mine. (51) Cf7. (52) Ce24 M. Smith mine. (53) Ce25 B. Smith mine. (54) De17 Bennett mine. (56) De7 Hillsdale No. 3 mine. (57) Dell Hillsdale No. 1 mine. (58) Ce14 Hillsdale No. 4 mine. (59) Ce22 Hoffman mine. (60) Ce7 Indiana No. 6 mine. (61) Ce13 Arcadia No. 5 mine. (62) Ce6. (63) De20 Whirwin mine. (64) Ee16 E. White mine. (65) Ee21 Gardner mine. (66) Fe6 Patchin mine.

The roof of this coal commonly is shale, though in parts of the area the Lower Mahoning sandstone rests on the coal and in places cuts into it. The floor almost everywhere is clay, with a thickness of two feet or more, and often four or five feet. Over this south central part

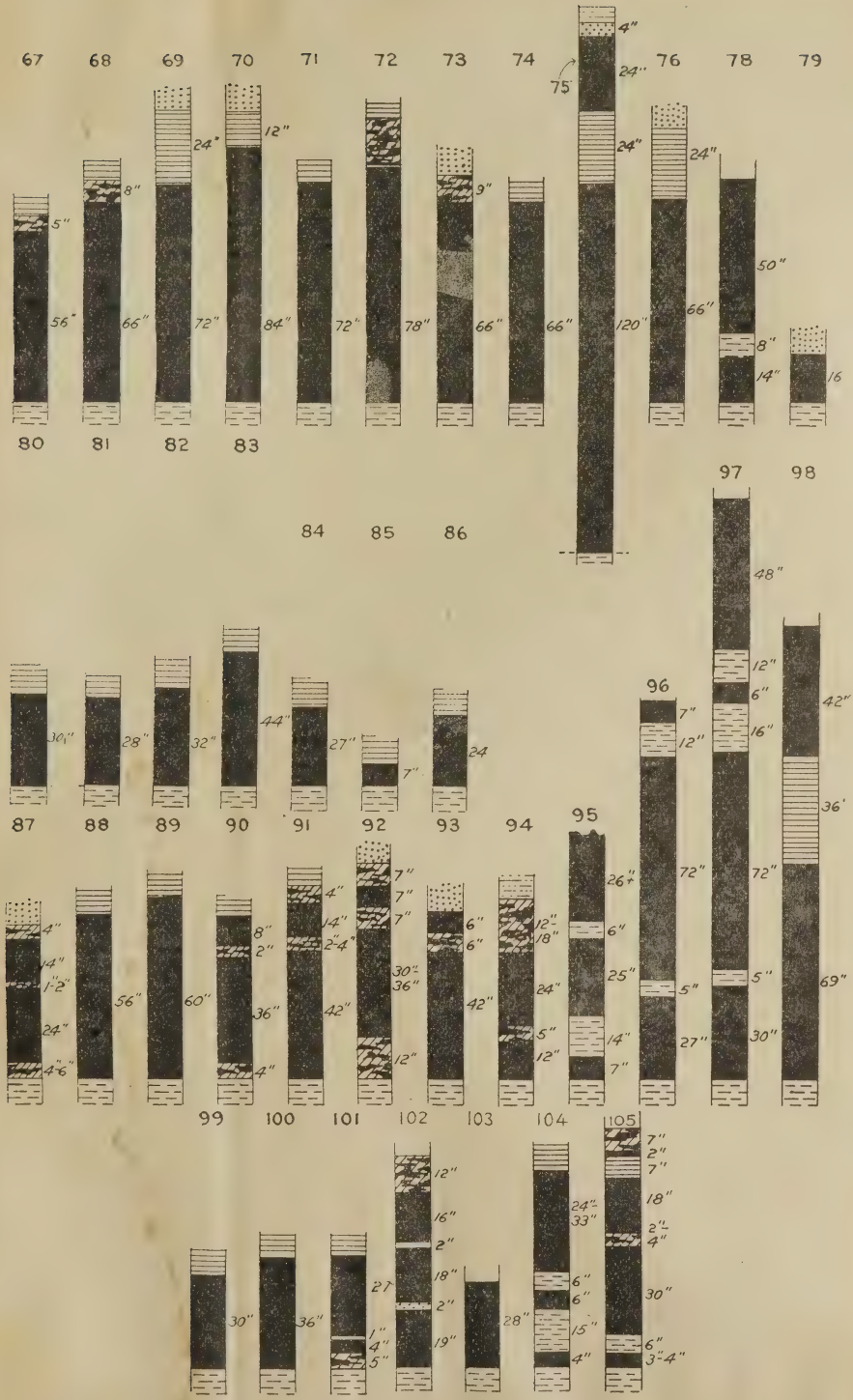

FIGURE 9. Selected sections of the Lower Freeport or D coal in the Punxsutawney quadrangle. See note to Figure 7.

(68) Aa22 Hagg mine. (69) Ae24 Walston No. 1 mine. (70) Aa 25 Walston No. 3 mine. (71) Ab2 Elk Run shaft. (72) Aa12 Adrian No. 1 mine. (73) Aa6 D. Staley mine. (74) Aa5 J. W. Browne mine. (75) Cal Eleanora shaft. (78) Db5 below Hillman mine (rep.). (80) Fa4. (81) Fb6 Clover Run No. 2 mine. (82) Fb5 Outcrop on road. (86) De9 below Indiana No. 3 mine. (87) De3 Glenwood No. 6 mine. (88) Dd13 Glenwood No. 6 mine. (89) Dd13 Glenwood No. 6 mine. (90) De5 Glenwood No. 5 mine. (91) Ee1 Glenwood No. 3 mine. (92) Ee6 (93) Ee3 Urey No. 5 mine. (94) Ed8 Urey No. 1 mine. (95) Ed7 Outcrop. (96) Ed9 Urey No. 2 mine. (97) Ed3 Cesna mine. (100) Ae11. (101) Be10. (102) Ee21 Bellmore mine. (103) Ee10 Indiana No. 7 mine. tKHETAET (102) Ee21 Bellmore mine. (103) Ee15. (104) Ee10 Indiana No. 7 mine. (105) Ee9 Indiana No. 1 mine.

of the quadrangle the section and thickness are remarkably regular, mine after mine showing almost identical sections. Toward the northwest, however, the bed becomes very irregular and in the Locust and Punxsutawney districts is locally absent or very thin. The position of this coal is shown on the geologic map (Plate II) by the contact between the Allegheny and Conemaugh groups.

Lower Freeport or D coal.

As shown by the sections in figure 9, the D coal is extremely variable in thickness. It has a magnificent development in the Punxsutawney district, averaging six feet or more in a very large area and up to 10 feet in places, though it is absent in a north-south belt running a little east of the center of the Punxsutawney district. Also it reaches a thickness of 9 feet or more in one small area in the Glen Campbell district. Over the quadrangle as a whole, however, it is irregular in thickness, though probably workable in a large part of the area it underlies. Its average thickness outside of the Punxsutawney district, probably is three feet or less. As a rule it is without partings or bony coal, though in some sections there is a small bench of bony coal at the top. Where the coal reaches its greatest thickness in the Glen Campbell region (see under that district), it is divided by rather thick partings into three or more benches. The roof usually is shale though a number of sections show sandstone. The floor practically always is clay. See plate VI.

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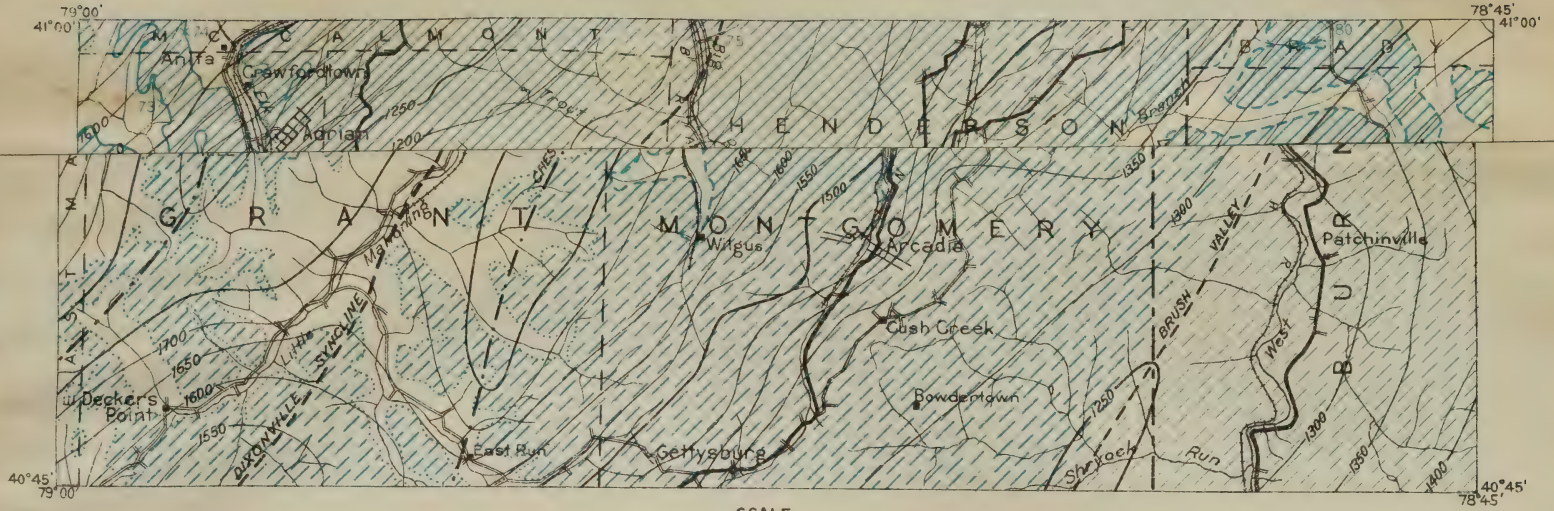
PLATE VI.



SCALE

1 0 1 2 3 4 MILES

Lower Freeport Coal

Coal 2' or more

Coal less than 2'

EXPLANATION

1500 Structure contours on Upper Freeport coal

Coal outcrops

Coal thickness uncertain probably 2' or more

Commercial mines

Small or abandoned mines

Coal probably less than 2'

Coal, position probably correct 2' or more (net) thick.

Coal, position in doubt 2' or more (net) thick.

Coal, position probably correct thickness not known.

MAP SHOWING THE DISTRIBUTION AND THICKNESS OF THE LOWER FREEPORT OR D COAL IN THE PUNXSUTAWNEY QUADRANGLE.

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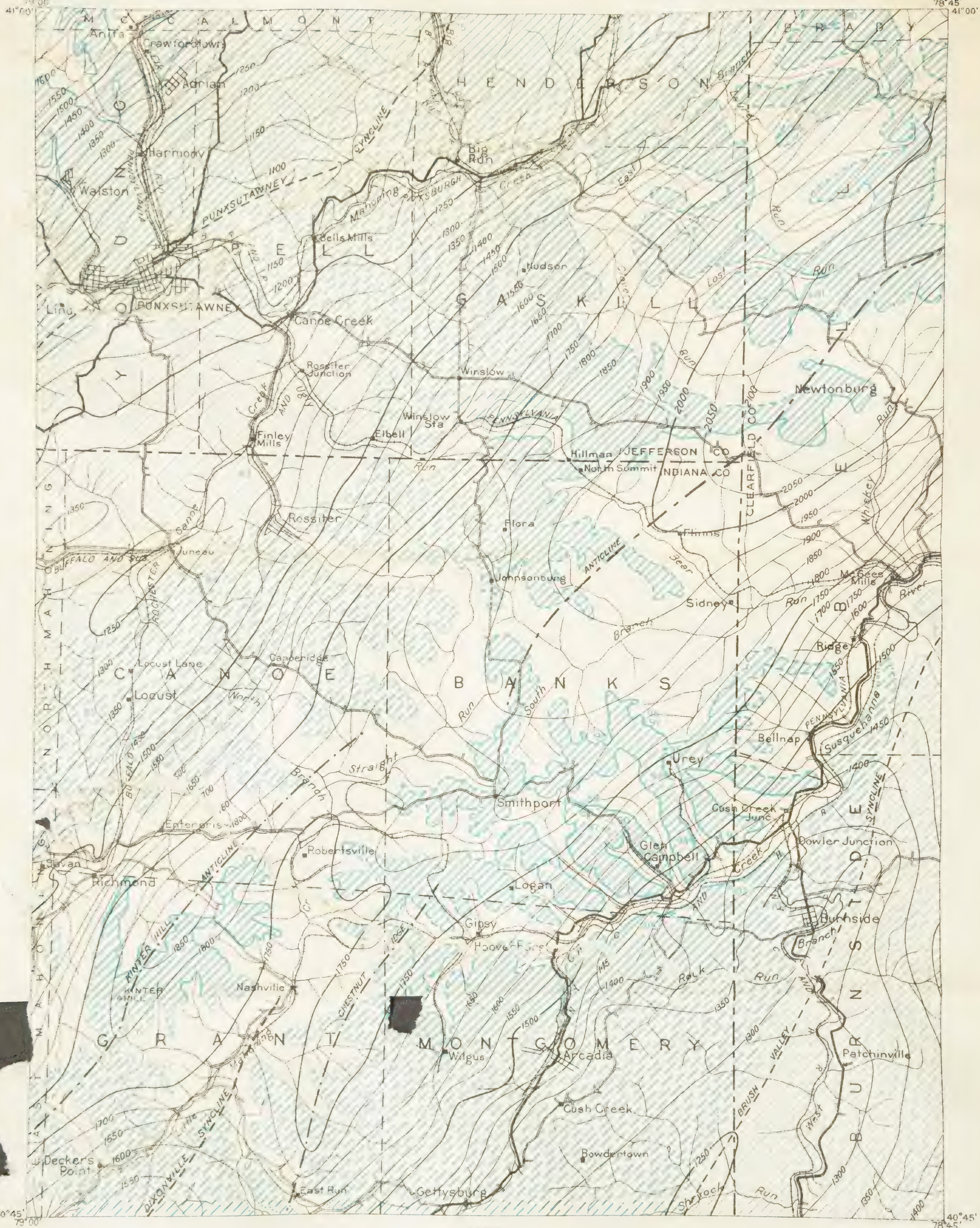
SHEET 65, PUNXSUTAWNEY

PLATE VI.



SCALE

0 1 2 3 4 MILES

EXPLANATION

Lower Freeport Coal

- Coal 2' or more
- Coal less than 2'
- Coal thickness uncertain probably 2' or more
- Coal probably less than 2'
- 1500 Structure contours on Upper Freeport coal
- Coal outcrops
- Commercial mines
- Small or abandoned mines
- Coal, position probably correct 2' or more (net) thick.
- Coal, position in doubt 2' or more (net) thick.
- Coal, position probably correct thickness not known.

MAP SHOWING THE DISTRIBUTION AND THICKNESS OF THE LOWER FREEPORT OR D COAL IN THE PUNXSUTAWNEY QUADRANGLE.

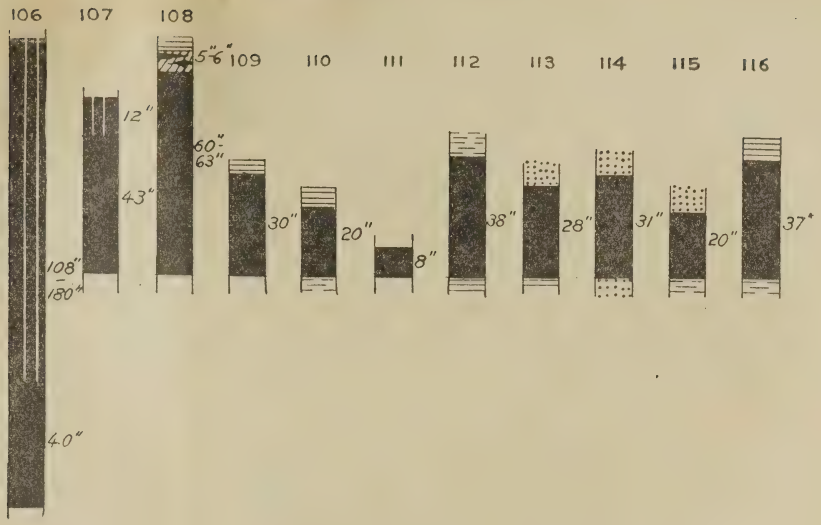


FIGURE 10. Selected sections of the Upper Kittanning or C′ coal. (see note under figure 7). (106) Af2 Altoona mine (maximum 9-15 ft.). (107) Af2 Altoona mine (minimum). (108) Ae6 A. Jeffries mine. (109) Ae5.

Upper Kittanning or C′ coal.

As shown by the sections, the Upper Kittanning coal reaches a workable thickness in spots but is generally too thin to work under present commercial conditions. This bed is characterized in Pennsylvania by tending to carry a certain amount of cannel coal, and one mine exists in this quadrangle where in part of the mine 9 feet of cannel overlay a bench of bituminous coal. Very few openings have been made on this coal, but many of the drillings show it to have a thickness of 2 feet or more, so that it may be assumed that ultimately it will furnish at least a small amount of coal to commerce. South of Richmond is a mine in a five-foot bed of coal that appears to be at this horizon.

Middle Kittanning or C coal.

As shown by the sections, the Middle Kittanning coal is very thin over most of the quadrangle, not being workable under present conditions. The thickness usually ranges from a few inches to 24 inches. The roof is usually shale and the floor clay.

Lower Kittanning or B coal.

The Lower Kittanning coal is exposed over a very small area only, so that our knowledge of it has been derived mainly from the very few wells that have pierced it. Such openings as exist, and the few

holes that have been drilled through it, suggest that it will probably prove of workable thickness over most of the quadrangle. It may average nearly or quite 3 feet. The only areas where it is now exposed are the Richmond, Newtonburg, and Glen Campbell districts. In these its section varies, in places showing no partings or bony coal and in others showing one or more partings and one or more benches of bony coal. Over the State as a whole, this coal is usually of moderate thickness but regular, so that it may be judged to maintain somewhat similar characteristics in this quadrangle. Usually so far as seen, the roof is shale and the floor 6 or 8 feet of clay.

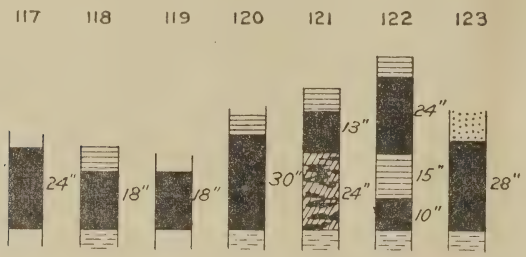


FIGURE 11. Selected sections of the Middle Kittanning or C coal. (121) N. Y. C. RR. cut just east of quadrangle. (122) N. Y. C. RR. cut Fd 1. (123) Fc15.

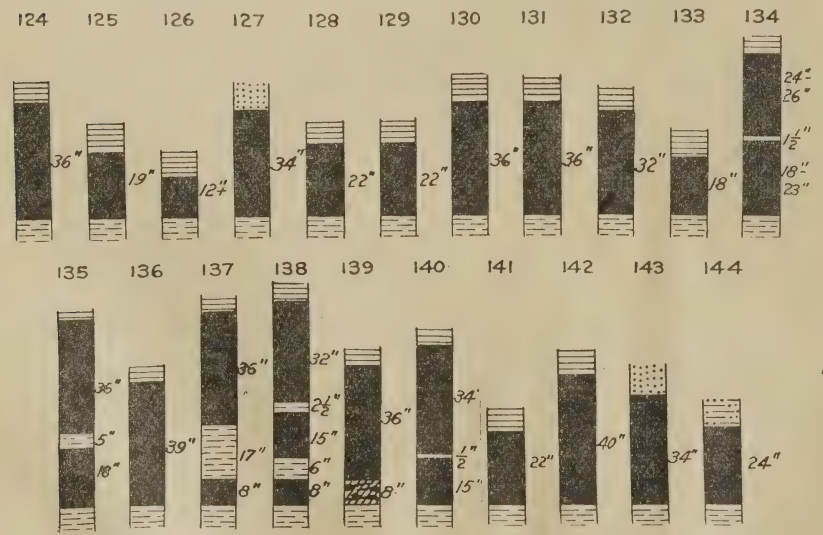


FIGURE 12. Sections of the Lower Kittanning or B coal in the Punxsutawney quadrangle. (see note under figure 7).

(126) Ad8. (127) Ea4 Schlimmer mine. (129) Fd3 RR. cut near McGees. (130) Bf2. (131) Bf3 C. Rodney mine. (132) Bf10 J. Romeley mine. (133) Bf1. (134) Ae4 RR. cut near Richmond. (138) (139) De10 Indiana No. 1 mine.

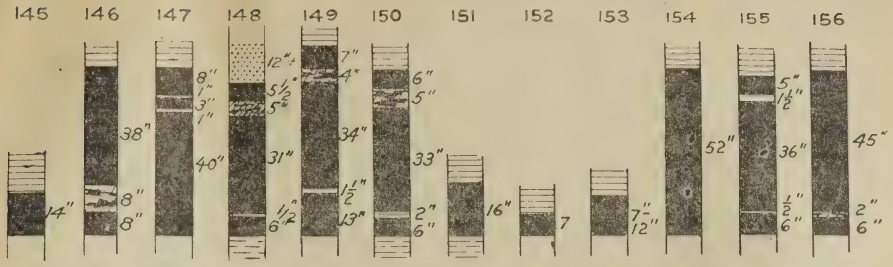


FIGURE 13. Selected sections of the Clarion and Brookville or A′ and A coals. (see note under figure 7). (145) Ec8 (Probable "B" coal). (146) Ec4 Bear Run No. 1 mine. (147) Ec7 outcrop in railroad cut. (148) Fc6 in deep railroad cut close to McGees station. (149-150) Fc4 McGee mine. (151) Fc8 railroad cut. (152) Ac17 outcrop beside road. (153) Be5 Outcrop beside road. (154) Dd2 Superior mine. (155) Ed 1 Bear Run No. 2 mine. (156) Ec13 Small mine.

Brookville or A coal.

It is not known whether the coal so designated here should be considered as representative of the Brookville or the Clarion coal. It is exposed over a considerable area in the Newtonburg and Glen Campbell districts, and although apparently of rather poor quality is usually of workable thickness. As very few drill holes have reached this horizon it is not known how generally this coal may be workable over the quadrangle. As a rule it has partings, and locally carries thin benches of bony coal. Shale immediately overlies the coal in most places but is generally very thin and overlain in turn by the massive Clarion sandstone. Under the coal, is from three to six feet of sandy clay.

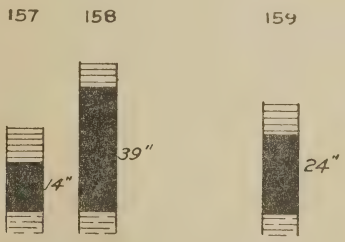


FIGURE 14. Sections of Mercer coals. (157) Ec6 outcrop in quarry (Upper Mercer). (158) Fc6 in quarry near McGees Station (uncertain) (Upper Mercer). (159) Fc3 outcrop (Lower Mercer).

Mercer coals.

Mercer coals were seen only in the area about McGees. None of the sections were clear cut and reliable. The two coals show in a ravine half a mile west of McGees Station where the section is: coal, (Upper Mercer) 22 inches±; clay,?; shale, 2 feet; sandstone, even bedded, 3 feet; shale, with lines of sandstone lenses, 10 feet; shale, drab, 10 feet; coal, about 2 feet; shale, dark drab, 2 feet. The Mercer coal in nearby areas has little value and little can be expected of these beds.

Chemical character of coals.

The table which follows gives analyses of samples taken from the large mines of this district. The samples were obtained in accordance with the usual method of sampling adopted by the U. S. Bureau of Mines, that is, by making a cut from the roof to the floor across the fresh face of the bed, rejecting the partings thrown out in mining. After the samples had been pulverized and quartered down, they were sealed in galvanized cans and sent to the laboratory of the U. S. Bureau of Mines for analysis.

Complete analyses of these coals are given in Bituminous Coal Fields of Pennsylvania, Part IV, Coal Analyses, published by the Pennsylvania Geological Survey in 1925.

Analyses of coal mine samples.

Location, name of bed.	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	Fuel value B.t.u.
Clearfield County.						
McGees Mills, Butter Ball mine, Middle Kittanning bed.	2.8	26.8	58.0	12.4	5.1	13,050
McGees Mills, Sherwood mine, Upper Kittanning bed.	5.6	26.0	60.3	8.1	1.3	13,280
Indiana County.						
Gypsy, ½ mile south of; Trojan mine, Lower Freeport bed.	2.9	31.0	60.5	5.6	2.2	14,190
Glen Campbell; Electric No. 8 mine, Lower Freeport bed, (composite of 2 samples)	2.6	27.1	60.5	9.8	1.6	13,380
Glen Campbell; Glenwood No. 9 mine, Lower Freeport bed.	3.3	23.4	67.6	5.7	.9	14,260
Glen Campbell; 1 mile east of; Falcon No. 8 mine, Middle Kittanning bed.	2.8	26.0	61.9	9.3	1.8	13,500
Glen Campbell; Falcon No. 9 mine, Lower Freeport bed.	3.0	26.1	58.5	12.4	2.7	12,960
Glen Campbell, 2 miles northeast of, on Horton Run; Indiana No. 2 mine, Lower Kittanning bed.	3.4	21.0	65.9	6.7	.7	14,150
Glen Campbell; Indiana No. 3 mine, Upper Freeport bed.	2.7	27.6	60.7	9.0	1.6	13,870
Glen Campbell; Indiana No. 6 mine, Upper Freeport bed.	2.9	26.9	61.7	8.5	1.2	13,720
Locust, ½ mile south of; Locust mine, Upper Freeport bed (composite of 2 samples).	3.2	31.0	57.0	8.8	3.1	13,530
Jefferson County.						
Big Run, McClure mine, Upper Freeort bed. (composite of 3 samples).	3.1	30.6	59.3	7.0	1.6	13,890
Punxsutawney, 1 mile south of; Williams Run No. 1 mine, Lower Freeport bed (composite of 3 samples).	2.7	32.9	59.2	5.2	1.1	14,180
Hillman, 2 miles east of; Arthur mine, Upper Freeport bed (composite of 2 samples).	3.9	29.0	58.6	8.7	1.9	13,400

As shown by the analyses the coal in this quadrangle is a "medium volatile" coal. According to the writer's classification it is a "midvol coal" or "coal 63," that is a coal having between 63 and 70 per cent

of fixed carbon on the ash-free basis, including moisture. The analyses given are "as received." These coals are low in moisture, generally low in ash; sulphur is variable. In grade some of this coal would pass as "superior" (less than 8 per cent ash and 1 per cent sulphur) according to the writer's classification, and most of the coal would pass as "good" (8 to 12 per cent ash, 1 to 1½ per cent sulphur).

For the sake of comparison, analyses are given of some of the other eastern high grade coals with which this coal is in competition. These are not individual analyses but approximate average figures.

Analyses of coal from competing fields.

Fields	Moisture	Volatile matter	Fixed carbon	Ash
Moshannon, Clearfield Co.	3.0	20.5	69.0	7.5
Barnesboro-Patton, Cambria Co.	3.0	22.0	67.0	8.0
Johnstown, Cambria Co.	3.5	15.5	71.5	9.5
Windber, Cambria-Somerset Cos.	3.0	14.0	75.0	8.0
Westmoreland.	2.5	30.0	58.5	9.0
Pittsburgh, Allegheny Co.	2.5	33.0	58.5	5.0
Connellsville.	3.0	28.5	60.5	8.0
Georges Creek, Md.	3.0	16.0	73.0	8.0
New River, W. Va.	4.0	17.5	74.5	4.0
Pocahontas, W. Va.-Va.	3.5	14.5	78.0	4.0

It must be realized that these figures are generalized and that the coals in these several fields differ from bed to bed and from one part of a field to another, just as the analyses of the Upper and Lower Freeport of this field differ. In general it may be observed that the coals of this quadrangle are intermediate between the so-called smokeless coals of the eastern edge of the coal field and the more bituminous coals of the Pittsburgh and Ohio regions. The figures tell their own story and the reader may draw his own conclusions.

These coals have been found by actual use to be good coking and steam coals. Much of this coal that is not coked is shipped to the northeast to New York and New England as a high grade steaming coal.

CLAY AND SHALE

Kinds of clay.

Three kinds of clay occur in the Punxsutawney quadrangle: first, the clay underlying the coal beds; second, flint clay; and third, alluvial clay, found in the stream valleys where it has been deposited as mud by flood waters.

Underclay.—As is well known, all the coal beds of this region are underlain with clay which may range in thickness from a few inches

to 6 or 8 feet. The top of this clay immediately under the coal is usually quite pure and lacking in sand or other extraneous material, but the lower part of the bed commonly shows an increasing percentage of sand or impurity toward the bottom. The underclay is generally more refractory than clay resulting from the weathering of shale. In some places the underclay is sufficiently refractory to serve in the manufacture of firebrick or at least in mixtures with flint clay.

Flint clay.—Flint clay is a non-plastic rock having the chemical composition of a pure clay or kaolin. It occurs usually as beds or

SKETCH MAP SHOWING LINES OF OUTCROP OF UPPER FREEPORT AND LOWER KITTANNING CLAYS AND APPROXIMATE LOCATION OF CLAY SECTIONS

FIGURE 15.

irregular lenses in other clays, especially in certain of the underclays, though in this quadrangle, as elsewhere, it sometimes occurs in the middle of a shale series. It takes its name from the fact that it is so hard, as to ring like limestone under blows of a hammer and breaks in fragments with sharp edges, like the fracture of flint that the Indians used for arrow heads. The occurrence and character of flint clay was described by the writer in some detail in the report of the Topographic and Geologic Survey Commission of Pennsylvania, 1906-1908, p. 313 and following.

Alluvial clay.—Alluvial clay is the common material for making building brick. It is found along all large streams and many small streams, both in the bottom lands and terraces. It consists of partly consolidated mud with a varying admixture of sand. It is plastic, varies in color, composition, and other characters. The alluvial deposits on the flood plains of MahoningCreek, Canoe Creek, and West Branch of Susquehanna River probably contain clay suitable for making common brick and tile. This clay is not utilized at present.

Distribution of clays.

The underclays have the same position on the map (fig. 15) as the coal beds. Less data are available on the clays than on the coal, as the underclays were not being worked at any point in the quadrangle, and their thickness and character were observed only here and there where exposed in the drainage ditch of a mine. The clays under the coals average about three or four feet in thickness, and are of better quality toward the top.

A comparison of these sections (figures 16, 17, and 18) shows that the Lower Kittanning clay has the greatest actual and average thickness, ranging up to 12 feet or more. If this clay has the same quality here as in other areas it will prove superior to the others. In most of the quadrangle this clay must be mined by shaft. Many of the sections given are from diamond drill records. The approximate locations of all sections are shown on the sketch map, figure 15, which indicates the outcrops of both the Upper Freeport clay and Lower Kittanning clay. The Lower Kittanning clay is used extensively in other regions for the production of a variety of clay products, including tile, and for mixing with flint clay to give plasticity.

The Upper Freeport clay (sections 1 - 22) ranks second in thickness and probably in quality. Its line of outcrop is long, so that over much of the quadrangle the clay could be mined by drifting. The clays under the other coal beds are of variable thickness, in places reaching 8 or 10 feet, but in general thinner than the two beds previously mentioned. All of these beds are worthy of testing in places.

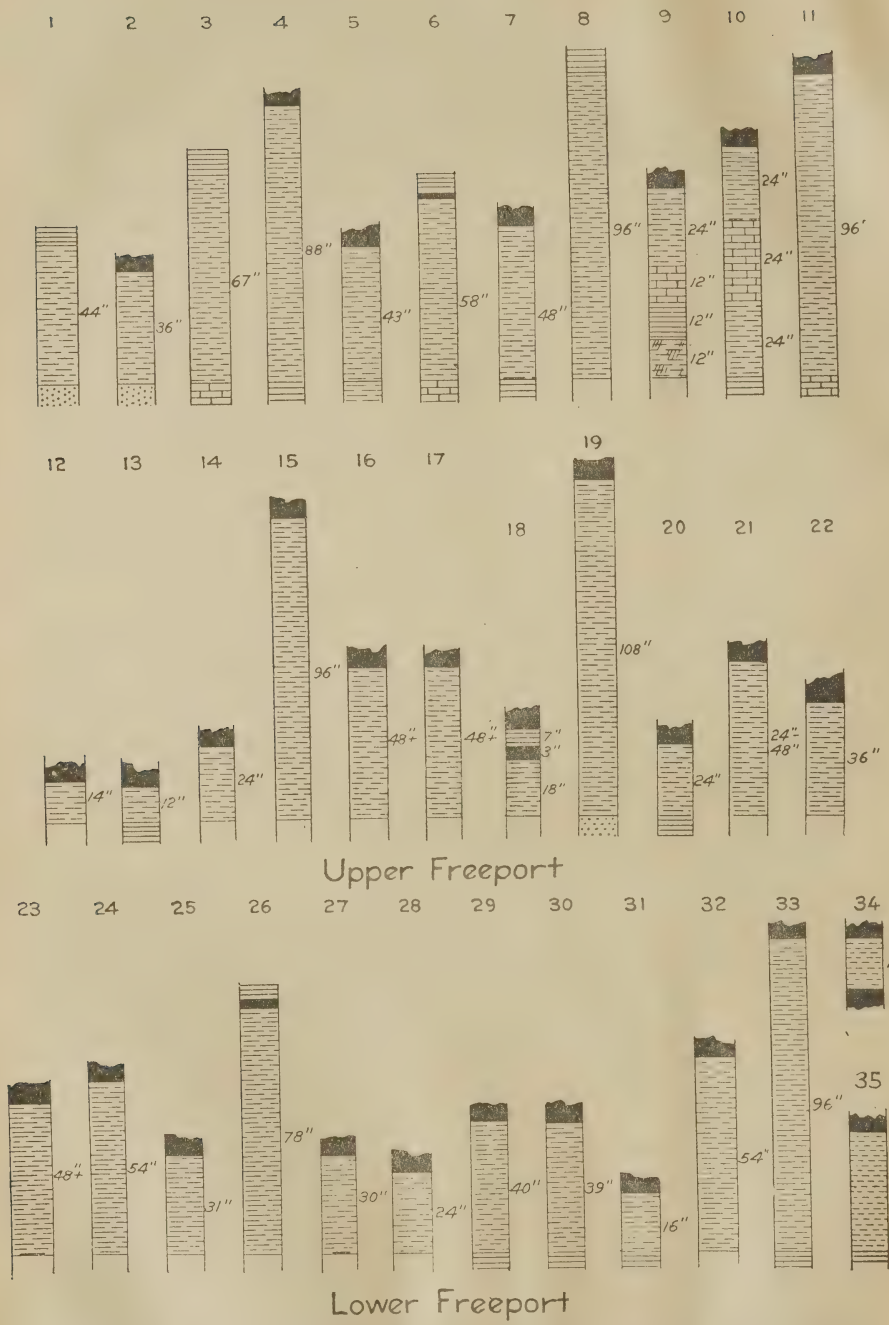


FIGURE 16. Columnar sections of Upper (1-22) and Lower 23-35) Freeport clay beds in the Punxsutawney quadrangle. The location of the several sections is indicated approximately by the sketch map, figure 15. Most of the sections are from drill holes.

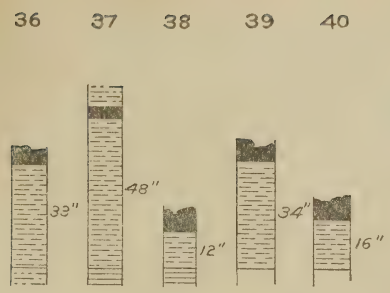


FIGURE 17. Columnar sections of Upper and Middle Kittanning clay beds in the Punxsutawney quadrangle. The location of the several sections is indicated approximately by the sketch map, figure 15. Most of the sections are from drill holes.

Scattered fragments of flint clay were seen at many points over the quadrangle, but at no point was a bed of flint clay of workable thickness seen in place. These scattered fragments give no basis either for considering the clay as workable or for condemning it. All the flint clay of the quadrangle appears at one or another of four horizons: (1), in the interval between the E coal and the Mahoning coal; (2), directly under the E coal; (3), under the B coal; and (4), at the Mercer horizon, which is believed to correspond with the position of the Mt. Savage fireclay of Maryland and most of the valuable fireclays of Clearfield County.

Smooth, fine-grained, olive shales usually occur in the interval between the E coal and the Mahoning coal. In places these tend to have the structure of flint clay, being hard and brittle, and in many places they actually grade over into flint clay of low grade. In the Johnstown quadrangle clay at this horizon is exposed abundantly near Wehrum and has been called the Wehrum flint clay. It has been mined upon a very small scale in several places, though not in this quadrangle, and as far as the writer knows, without financial success. As a rule the flint clay at this horizon contains too much iron.

The flint clay occurring immediately below the E coal is believed to be the same as the Bolivar flint clay. This latter is immediately below the limestone which underlies the underclay of the E coal. Among the places where clay was seen at this horizon are six localities (Af 3, Ae9, Bd5, Bf4, Ce1, and Ce5) shown on the map (Plate III).

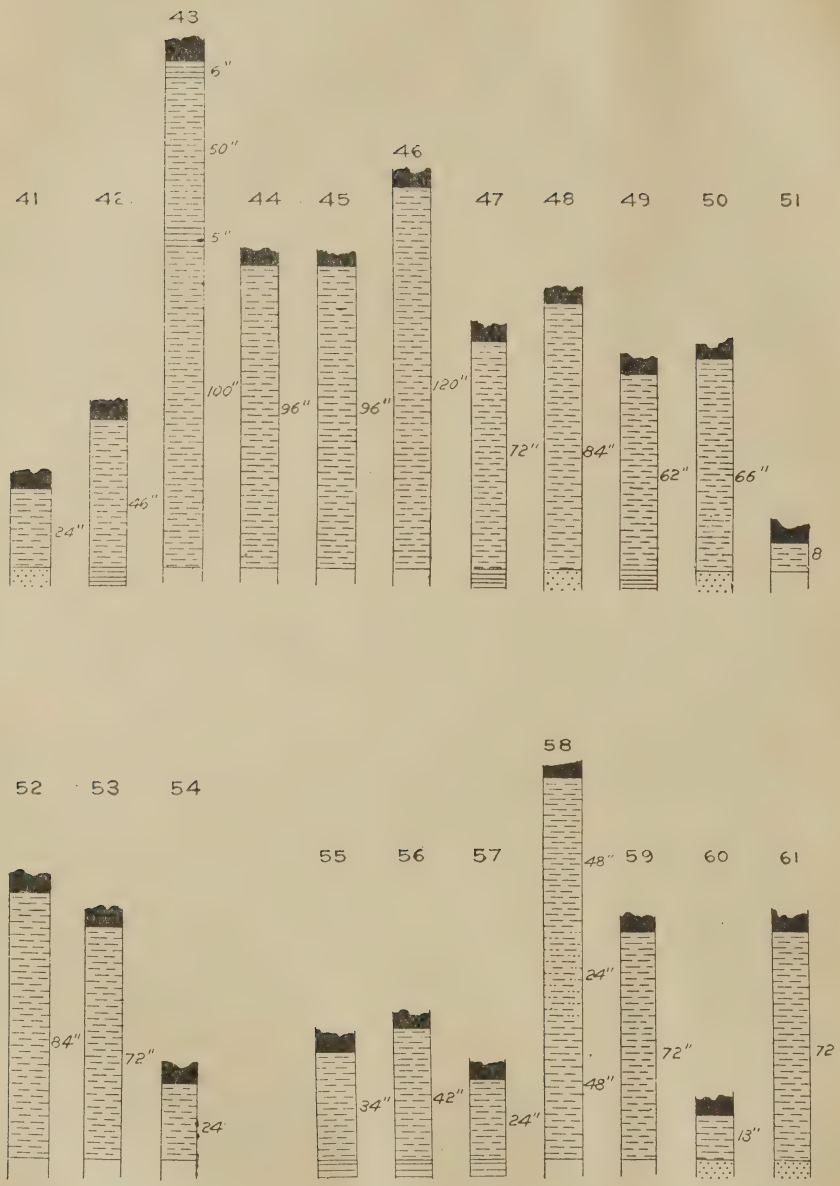
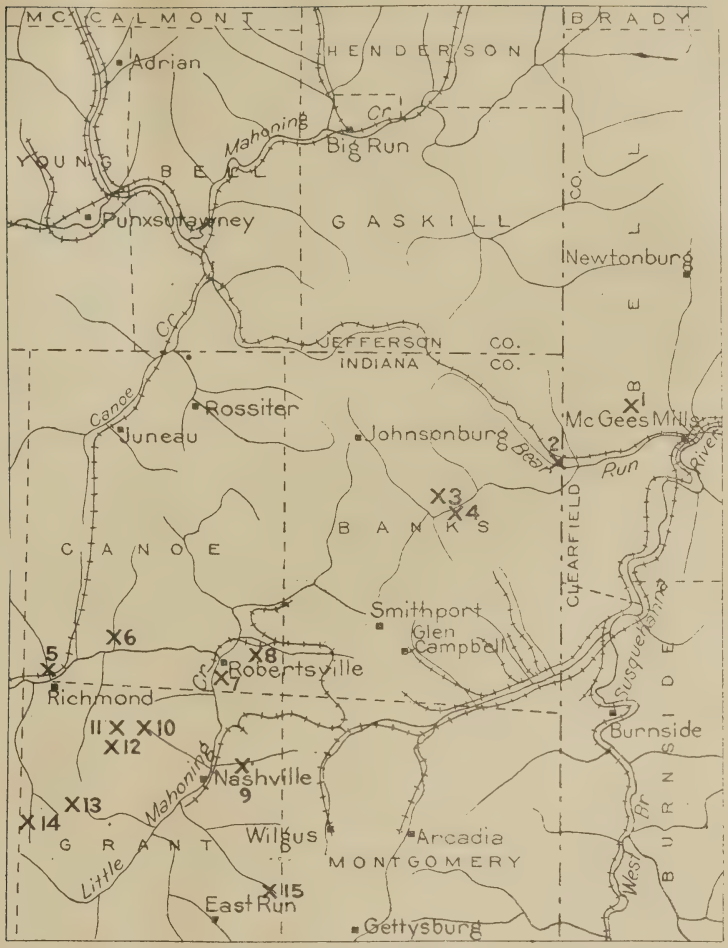


FIGURE 18. Columnar sections of Lower Kittanning (41-54) and Brookville (55-61) clay beds in the Punxsutawney quadrangle. The location of the several sections is indicated approximately by the sketch map, figure 15. Most of the sections are from drill holes.



SKETCH MAP SHOWING APPROXIMATE LOCATION OF OUTCROPS OF FLINT CLAY

NO.	HORIZON	NO.	HORIZON	NO.	HORIZON
1	Clarion	6	Clarion	11	Wehrem
2	Mercer	7	Clarion	12	Wehrem
3	Clarion	8	Upper Freeport	13	Wehrem
4	Clarion	9	Upper Freeport	14	Wehrem
5	Clarion	10	Upper Kittanning	15	Wehrem

FIGURE 19.

The flint clay underlying the B coal is supposed to correlate with the flint clay found so abundantly in Clarion County and occurring in the streets of the town of Clarion. Flint clay at that horizon was seen at map stations Be5, Dd1 and 3, and elsewhere. At Ad8, flint

clay was found at this horizon intermingled with sandstone and of course worthless. Whether the flint clay at any of these horizons is of any value must be determined by prospecting. Flint clay at the Mercer horizon was seen at only one point, along the railroad track just above the station at Sidney.

Shale.

Although no shale was seen in the quadrangle that at once suggested itself as especially suitable for the manufacture of paving brick or other clay products, nevertheless much shale between the several coal beds appears to be fairly suitable for that use. Certain shales in the Conemaugh group may be usable. The shales between the E or Upper Freeport coal and the position of the Mahoning coal are fine grained and argillaceous, and the shales overlying the Brush Creek coal, though usually sandy, would locally seem to be fairly well suited for the manufacture of paving brick. These shales are being used at one or two points near Punxsutawney for the manufacture of paving brick. Most of the shales of the Allegheny group in this area are fairly sandy, as a rule too much so for the manufacture of fine brick, though doubtless well suited for the manufacture of ordinary building brick. As the shales are common all through the group, it follows that they are abundantly distributed all over the quadrangle and it is hardly necessary to call attention to special localities.

LIMESTONE

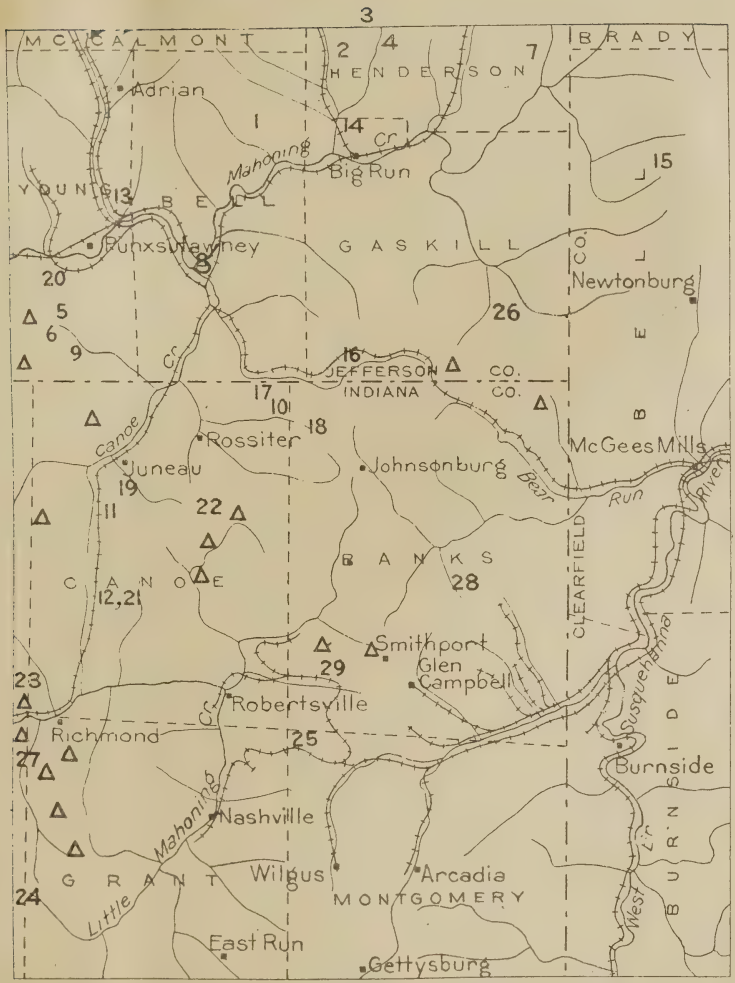
Limestone horizons.

The limestones of the Punxsutawney quadrangle occur at two horizons in the Allegheny group and apparently three horizons in the Conemaugh.

The limestones in the Conemaugh occur at the following elevations above the Upper Freeport or E coal:

	Ft.
Mahoning limestone	50-70
Brush Creek limestone	100-120
Woods Run limestone	220-240
Ames limestone	315

The Upper Freeport limestone, which occurs from 1 to 20 feet below the Upper Freeport or E coal, is apparently the most persistent and much the most widespread. It shows a thickness of 1 to 10 feet or possibly more. Sections 14 and 19, figure 22, reported from wells by the Second Geological Survey, may not be reliable. Certainly such thicknesses as 15 and 21 feet are not common elsewhere.



SKETCH MAP SHOWING APPROXIMATE LOCATION OF LIMESTONE SECTIONS

Δ Limestone outcrop - no section

FIGURE 20.

The Vanport limestone, which occurs some 30 feet below the Lower Kittanning or B coal, was found in this quadrangle only near Richmond. There it is a high-grade, white limestone. That it occurs elsewhere in the quadrangle is to be expected, especially north of Richmond.

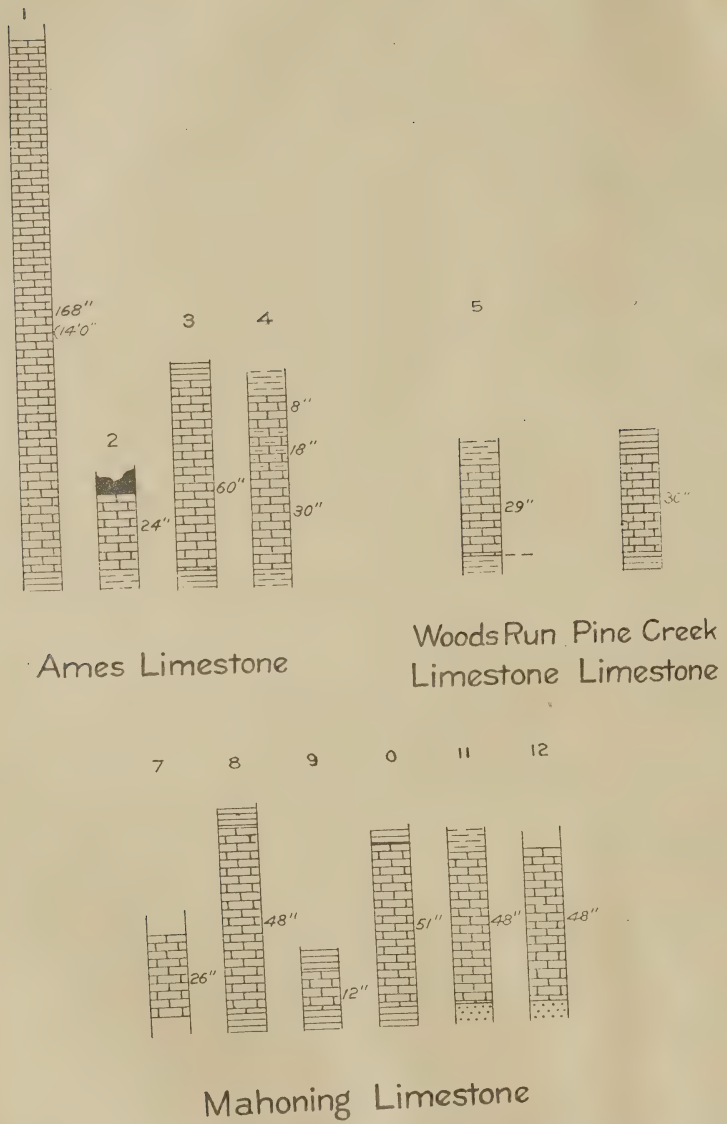


FIGURE 21. Sections of limestone beds of Conemaugh group in the Punxsutawney district.

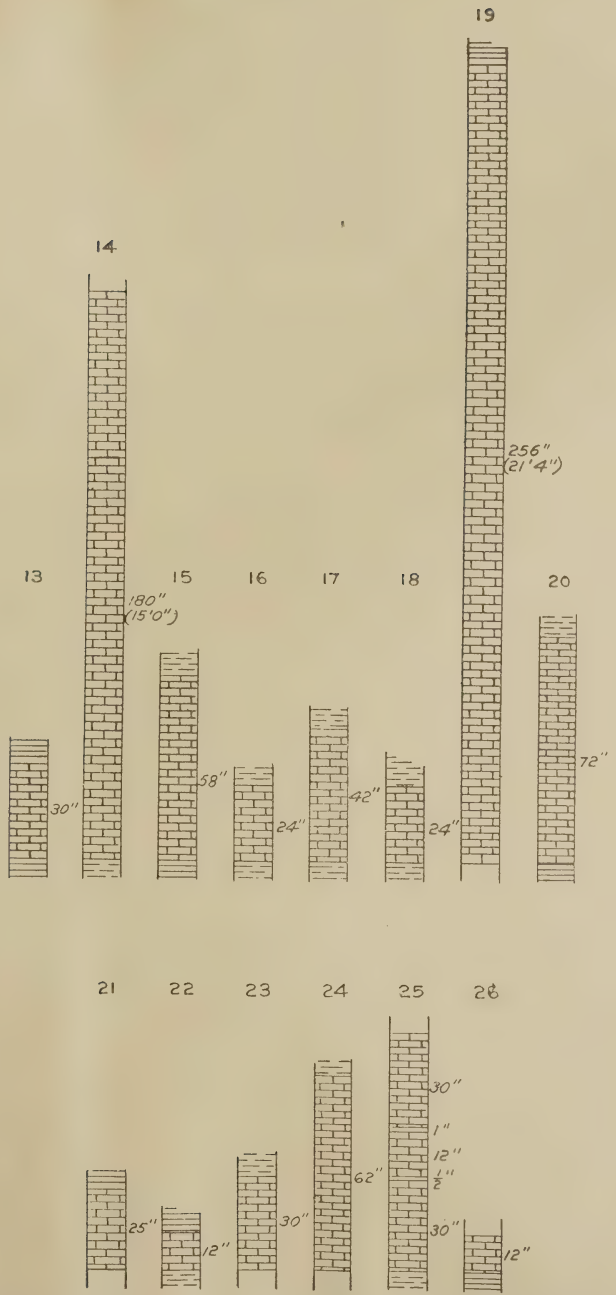


FIGURE 22. Sections of Upper Freeport limestone in the Punxsutawney quadrangle.

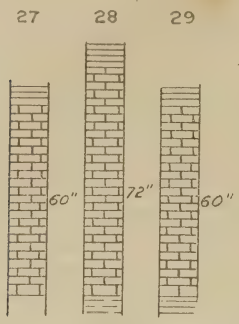


FIGURE 23. Sections of Vanport limestone in the Punxsutawney quadrangle.

Analyses.

The report of the Second Pennsylvania Survey for Indiana County gives analyses of two of these limestones, the Vanport and Upper Freeport.[2]

Analysis of Vanport limestone near Richmond.

Calcium carbonate	92.857
Magnesium carbonate	1.589
Iron and aluminum oxide	2.030
Sulphur	.187
Phosphorus	.035
Insoluble residue	2.090

From this analysis the Vanport limestone may be assumed to have the same high grade that it has in a large area to the west and northwest, and to be available for the same purposes,—cement making, iron smelting, and lime.

The analyses of three layers of the Upper Freeport limestone from an exposure 1½ miles southwest from Smithport are given next. The limestone consists of three layers, the upper and lower of which are each 2 feet 6 inches thick and the middle layer one foot thick, separated by clay bands from 1 to 12 inches thick. The first analysis is of the upper 30 inch bed of limestone.

Analysis of upper bench of Upper Freeport limestone near Smithport.

Lime carbonate	36.214
Magnesium carbonate	16.883
Iron carbonate	8.078
Alumina	4.360
Sulphur	.056
Phosphorus	.056
Insoluble residue	32.790

[2]Platt, W. G., Report of progress in Indiana County: Pennsylvania Second Geol. Survey, Report HHHH, pp. 260-264, 1878.

This layer of limestone, or dolomitic sandstone, as indicated by the analysis, would not make a good lime, nor would it be suitable for the manufacture of Portland cement or for the reduction of iron. It is a light gray in color, compact and very hard, and when burned does not calcine and slack into lime. The other two layers gave the following analysis:

Analysis of middle and lower benches of Upper Freeport limestone near Smithport.

Lime carbonate	58.750
Magnesium carbonate	16.005
Iron and aluminum oxide	7.380
Sulphur	.041
Phosphorus	.085
Insoluble residue	15.060

While these three analyses may not be quite representative it is believed that they exhibit well the difference in quality of the Vanport and Upper Freeport limestone, as judged by other analyses of the same limestones elsewhere. In other words, the Vanport limestone is likely to be high grade limestone of commercial importance and the Upper Freeport limestone, while often in part or in whole suitable for burning for agricultural lime, is not as a rule sufficiently pure for the higher uses of lime.

SANDSTONE

Although no high grade sandstone was seen in the Punxsutawney quadrangle, sandstones occur at several horizons that have been found suitable for rough structural work such as bridge abutments, etc. The most promising sandstones are at two horizons, one in the lower part of the Allegheny and the other in the lower part of the Conemaugh group. The Pottsville sandstones as exposed in this quadrangle do not give promise of being of value. The Homewood sandstone outcrops around McGees Mills and up Bear Run but nowhere makes prominent cliffs or gives other evidence of being suited for structural uses. Where seen it is a light brown to light drab sandstone of medium grain. It outcrops also in Little Mahoning Creek above Richmond, but was not seen, owing to the large quantity of debris coming down from the Clarion sandstone higher on the slopes.

The Clarion sandstone, close to the base of the Allegheny group, is a massive sandstone over a considerable area north and northwest of McGees Mills and east of Richmond. Large structural stones have

been quarried a short distance west of McGees Mills and shipped away, and large fragments were ground at McGees Mills for building sand. The Clarion sandstone about 40 feet thick shows boldly in the railroad cuts where the New York Central crosses over the Pennsylvania and Northwestern division of the Pennsylvania Railroad at

SKETCH MAP SHOWING AREAS OF OUTCROP OF MASSIVE SANDSTONE

Massive phase of Saltsburg sandstone
Massive phase of Upper Mahoning sandstone
Massive phase of Clarion sandstone
Areas of massive sandstone of limited extent

FIGURE 24.

McGees Mills. It is a light-brown, irregular bedded sandstone, conglomeratic toward the bottom but becoming shaly and softer toward the top. It keeps above drainage up Whiskey Run and the tributaries of Whiskey Run and Bear Run, and the other streams entering Susquehanna River near McGees Mills.

The same sandstone is prominent around Richmond in Grant and Canoe townships. It dips below Little Mahoning Creek between Richmond and Savan, the town of Richmond being built on its surface. From there the rise of the rocks to the east carries it up, so that it outcrops as a prominent cliff around the crest of the slope where Beach Run and Barnett Run unite on the south side of the creek opposite Enterprise. The only other prominent sandstone noticed in the Allegheny group was the Freeport sandstone that caps the hills over a large area in the center of the quadrangle.

About 50 to 70 feet above the base of the Conemaugh group is the base of a massive sandstone that outcrops over a large area in Gaskill and Bell townships in Jefferson County and in Bell township of Clearfield County. It is 30 to 40 feet thick and is overlain by a thinner bedded, less massive sandstone. It crops out on Mahoning Creek, a short distance west of Cloe post office, rises eastward to the crest of the upland around Winslow post office and continues to form the crest of the hill eastward past Newtonburg and northeastward into the Curwensville quadrangle. Over most of this area, though it does not form cliffs, the sandstone supplies a mantle of large blocks that strew the surface of the upland and the valley slopes. It is not being quarried at present, probably because of its position on the top of the hills, while the railroads are mainly in the valleys. Part of the sandstone is too conglomeratic to be of great value, but a careful search will doubtless reveal many areas of stone well suited for use in bridge building and other rough structural work. The same sandstone is massive and outcrops at many other places, at one of which two miles north of Glen Campbell, a small quarry has been worked.

Higher in the Conemaugh are at least three sandstones which may locally prove of commercial value. One of these has its top about 200 feet above the base of the Conemaugh or the top of the Upper Freeport coal. This sandstone is conglomeratic and massive on the hilltop just southwest of Savan, on the hill just southwest of Rossiter, around the slope just northwest of Juneau, and elsewhere. About 280 feet above the Upper Freeport coal is a sandstone that is quite massive around Hillsdale and along the ridge to Bowdertown and to the northeast, and on the ridge east of the West Branch of Susquehanna River in Burnside township of Clearfield County. Some 80 feet higher in the same general region is the top of another sandstone. Both of

these sandstones, though not seen in cliffs or other bare outcrops, in places yield quantities of large-sized boulders that suggest their availability for rough structural uses.

OIL AND GAS.

Between 60 and 70 wells have been drilled for oil and gas in this quadrangle. Some of these, especially in the area between Juneau and Punxsutawney, struck enough gas to justify piping to Punxsutawney. Most of these wells start in the Conemaugh, and obtain their gas mainly from two horizons, one about 1000 feet below the Upper Freeport coal and the other about 2550 feet below the Upper Freeport coal. The upper sand may represent the Berea and the lower one of the Devonian sands about in the position of the Speechley or Tiona. The Fifth sand gave "shows" of gas in some of the wells. The Berea sand, assuming the first sand to correlate with that sandstone, is from 1100 to over 1300 feet below the surface in the field near Juneau. The pay sand is from 2 to 50 feet thick. In some wells the gas seemed to come mostly out of the top of the sand. In others the volume increased with depth in the sand. In some wells no gas sand was found, in others as much as 50 feet of gas-yielding rock was passed through. As a rule, the gas sand has a thickness of 15 to 30 feet. Some of the wells got barely gas enough to light, and others had an initial pressure of as much as 425 pounds. In the well having the highest pressure the gas blew itself out in two months. The best wells showed from 40 to 300 pounds pressure. The wells which struck no gas sand or gas, or only little gas, were abandoned at once. Some produced for a year or two, others were still producing in 1905. The field was drilled between 1887 and 1900. One well in this group of old wells was still producing in May 1925.

A few feet above the "Gas sand" occurs the "Salt sand" which yielded a little gas in a few wells. Gas in one or two wells was thought to come from the 100 foot sand.

A number of the wells drilled from 2700 to 2900 feet deep, found a productive sand 10 to 30 feet thick at 2620 to 2850 feet in depth. This sand is 1500 to 1600 feet below the first productive sand, and is thought to be about in the position of the Speechley or Tiona sand. It is usually a hard white sandstone, and the gas coming from it had an initial pressure of 15 to 140 pounds.

Examination of the structure map shows that this area northwest of Juneau represents a slightly domed bench on the northwest side of the principal anticline in the quadrangle. The fact that gas has been found there suggested many years ago that drilling on the crest of the anticline might also find gas. Since 1905 further drilling has

included wells on the broad crest of the anticline running from a few miles south to the northeast corner of the Punxsutawney quadrangle along the crest of the ridge north of Newtonburg, past the northeast corner of Indiana County, south of Johnsonburg, through Smithport, west of Gipsy, west of Wilgus, and leaving the quadrangle near East Run. Well number 51 on Plate III is reported to have shown 60,000 cubic feet of gas. Other wells on the anticline are reported as dry. At the same time it might be worth while to try out the Kinter Hill anticline, running from a mile or so north of the southwest corner of the quadrangle, northeast through the center of Kinter Hill and on across Little Mahoning Creek near the mouth of Rishell Run. The flanks of the broad anticline which follows about the direction given of the synclines on either side have proved gas-bearing at several places as shown on the map, though a majority of holes in this area have proved to be dry or to give only a show of gas. It should be understood that this area appears to be outside of the oil region, as the easternmost oil wells lie west of a northeast-southwest line which crosses the Clarion and Kittanning quadrangles. Past experience indicates that no oil should be anticipated in this region.

The following table, furnished by the T. W. Phillips Gas & Oil Company (formerly Mahoning Gas & Heat Co.), is a summary of the results of borings in the Juneau field in the Punxsutawney quadrangle as of 1905.

Gas wells in the Punxsutawney quadrangle.

No. of well.	Year drilled.	Year abandoned.	Casing.	No. of sand.	Depth to top of sand.	Thickness of sand.	Depth to bottom of well.	Initial pressure.		Notes.
								Pounds per square inch.	Time.	
			Feet.		*Feet.*	*Feet.*	*Feet.*			
1				Third	2,620		2,680			
2	1887	1892		Third	2,710	10	2,720			
3	1889	1890	750	Third	2,802	15	2,828			Not good; sand hard and close.
4	1889	1892	1,250				2,814			
5	1890						2,777			No gas; no gas sand.
6		1903	1,165	Third	2,755	18	2,790	15		Very hard white sand.
7			1,277				2,907			Dry sand, hard, close, black.
8	1891		1,118	First	1,166	24	1,200			
	1894			Third	2,715	30	2,757			
9	1892			First	1,209½					Cased to about 700 feet.
	1894			Second	1,975		2,000			No gas.
10				First	1,242	49	1,297½			Small amount of gas.
11	1893			First	1,122	26½	1,154	40	30 min	Gas at 675 and 800 feet.
12	1894			First	1,153	37	1,190			
13	1894			First	1,231	2	1,311			Gas at top of "Salt" sand threw water over top of derrick at intervals for 3 or 4 days.
14	1894			First	1,102	20	1,243½			Just gas enough to light.
15	1895		1,239	Third	2,833⅜	22	2,858	140	2 days	
16			750	Third	2,864	10+	2,877			Gas increased from 2,864 to 2,874 feet, the gas being on top of sand, as in Nos. 4, 6 and 15.
17	1895	1895	757	Third			2,933			No gas sand; no gas.
18	1896	1897	1,125½	Third	2,858	17	2,885	115	5 min	
19	1897	1897	1,114	First			1,242			No gas sand or gas.
20	1897	1897	1,035	First	1,120		1,220			No gas or sand.
21	1897	1897	1,050	First	1,150		1,170	310	24 hrs	Good well.
22	1898		1,218	First	1,316	6	1,333	145	24 hrs	
23	1898		1,152	First	1,227	29+	1,272			Most gas at 1,256 feet.
24	1899	1899					1,301			Dry.
25	1899		842 574	First	1,164	15	1,188			Small well, better than No. 22 or 23; not equal to No. 21.
26			969	First			1,409			Very little gas.
27			844				2,000			
28	1900		776	First	1,220			425		Gas blew out in 2 months.
29	1900		776	First	1,300		1,341			
30			1,263	First	1,368					

During the last 20 years much additional drilling has been done in the quadrangle. Some of this drilling is still in progress, notably on Clover Run where Mr. F. C. Deemer of Brookville is drilling a well that in Feb. 1926, was more than 6955 feet deep.

Through the courtesy of the T. W. Phillips Gas and Oil Company and others, the approximate locations of the drill holes outside of

the Juneau pool are shown and some notes given. This may not include all the wells that have been drilled.

Additional gas wells in Punxsutawney quadrangle.

	Farm or Company	Depth to sand. Feet	Thickness of sand. Feet	Total depth. Feet	Notes
31.	W. C. Macek,			1,600+	Producer
32.	Jos. Cary,			3,360	Producer
33.	T. E. Long,			1,630	Producer
34.	F. P. Noerr,	1,365	10	3,446	Producer 100 ft. sand
35.	Francis D. Pringle,			3,516	Producer
36.	Mary A. Strope,			3,430	Producer
37.	W. H. White,			1,855	Producer
38.	E. G. North No. 2,	1,065 1,423 3,100	 22 26		
				3,330	Producer
39.	E. G. North No. 1,			3,840	Producer Gas at 1065, 1423 and 3100.
40.	S. & E. E. North,			3,315	Dry
41.					Producing
42.					Old, abandoned
43.					Old, abandoned
44.					Old, abandoned
45.	H. W. Weaver,	2,050	54	3,300	Dry, little gas in Warren
46.	Wm. T. Piper,	3,170	100		Dry, little gas
47.	F. C. Deemer,			6,500+	Drilling, May, 1925
48.	F. C. Deemer,			3,552	Dry
49.	Alice M. Irvin,				Show of gas
50.	Madeira Hill Coal Co.,			2,700	Dry
51.	J. A. Duff,			3,540	60,000 cu. ft.
52.					Dry
53.				3,000+	94,000 cu. ft.
54.				3,000+	Dry
55.				3,000+	Dry
56.					Dry
57.	Griffith,				Show of gas
58.	Tygart,	800		2,600+	300,000 cu. ft.
59.	Cockran,				Dry
60.	Leasure,				200,000 cu. ft.
61.	Leasure,			641	50,000 cu. ft.
62.				2,700	Show of gas
63.	Luella Oberlin,				Show of gas, shallow
64.	Ella M. Hurd,				Show of gas, shallow
65.	J. J. Smith,			2,751	Dry

IRON

Iron is an inconsiderable resource in the Punxsutawney quadrangle. The Mahoning limestone, from 50 to 70 feet above the Upper Freeport coal, in the Conemaugh group, is usually very ferruginous, so much so that in places it might serve as an iron ore when mixed with richer ores. This limestone shows at several points near Punxsutawney,—in the bed of Mahoning Creek ¼ mile below the bridge north of Lindsey; in a railroad cut near Williams Station, and elsewhere. An analysis of the limestone at Clayville (now a part of Punxsutawney), made by McCreath for the Second Pennsylvania Survey and given in report H, p. 183, yielded as follows:

Analysis of ferruginous limestone or iron ore at Punxsutawney (Clayville).

Iron	21.1
Sulphur	.127
Phosphorus	.493
Insoluble residue	30.010

Though not noted in the analysis, it may be assumed that the rest of the rock was carbonate of lime. This ferruginous limestone was called Freeport (?) limestone by the Second Survey.

Just beyond the eastern edge of the quadrangle in the road cutting a short distance west of Mahaffey appears a bed about one foot thick of low grade iron ore (limonite) at about the position of the Buhrstone ore of western Pennsylvania. The Buhrstone ore lies immediately above the Vanport limestone. It is possible that ore in that stratigraphic position will be found elsewhere in the quadrangle and possibly may be found of workable thickness and quality. The Second Pennsylvania Survey reports give an analysis of iron carbonate ore occurring as nodular masses of various sizes in sandy shales about four miles southeast of Punxsutawney (near Rossiter) in Indiana County on the G. Schlimmer farm. Though a large amount of iron appears here, at no one place are the ore balls packed close enough together to make a workable bed of iron ore. An analysis of this ore follows:

Analysis of iron ore on Schlimmer farm near Rossiter.

Iron	26.500
Sulphur	.141
Phosphorus	.149
Insoluble residue	34.460

The ore is described as a carbonate ore, hard, compact, siliceous, of a bluish gray color with conchoidal fracture. At one point some five miles southeast of Punxsutawney an attempt had been made to mine the red shale of Conemaugh age. To determine the amount of iron in it an analysis was made by the Second Survey which showed the shale to contain not more than 10 per cent of metallic iron. At many places over the quadrangle lenticular masses of iron carbonate were noted, but at no place were these in sufficient abundance to suggest the possibility of their being worked as iron ore. At the present time it may safely be said that while much iron occurs in the quadrangle it is not known anywhere in such concentrated form as to be of commercial value.

DETAILED GEOLOGY BY DISTRICTS.

For the purpose of detailed description of the resources of the quadrangle, it has been arbitrarily divided into a number of so-called "districts," the line of separation following as a rule the major drainage lines. The following sketch map shows the location and names of the several districts; the numbers show the order in which the districts are described in the text.

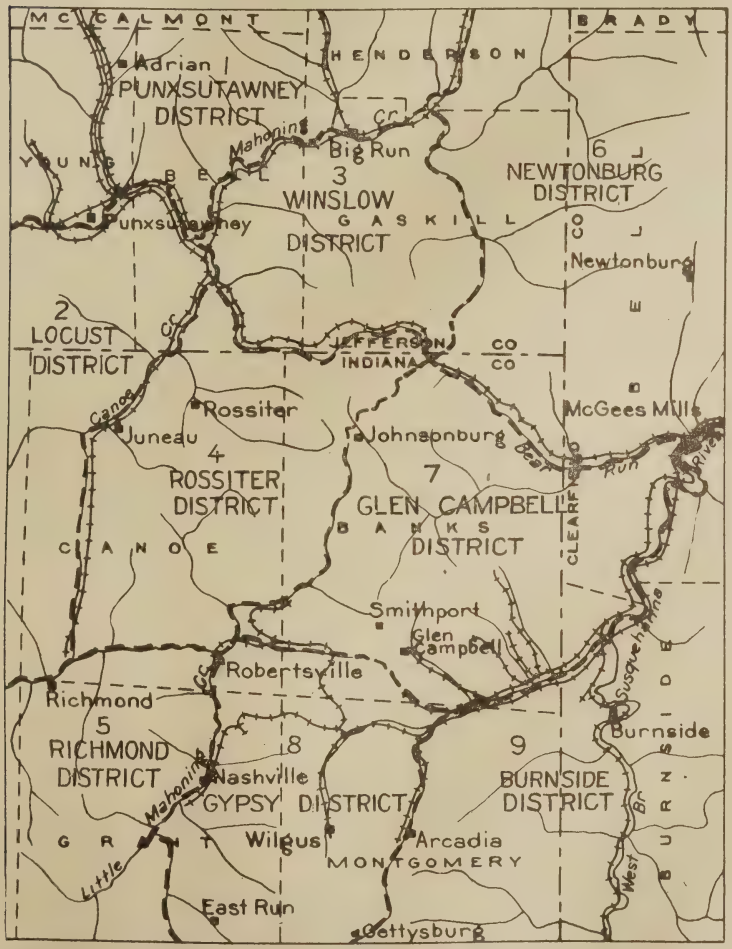


FIGURE 25. Sketch map showing division of Punxsutawney quadrangle into districts.

PUNXSUTAWNEY DISTRICT

Introductory statement.

The Punxsutawney district consists of the land in this quadrangle north of Mahoning Creek. The valley of Mahoning Creek on the south side of the district ranges in elevation from about 1230 feet below Punxsutawney to 1300 feet where the stream enters the quadrangle. North of the stream the hills rise abruptly to flat tops from 1400 to 1500 feet above sea level. Farther from Mahoning Creek the hilltops rise to 1600 feet, and a few points reach 1700 feet above sea level. Sawmill Run, Elk Run, Cold Spring Run, Rook Run, Trout Run, Big Run, and Windfall Run are the principal streams from the north. They are from 100 to 200 feet below the adjacent hilltops. The valleys have steep sides, and the hills round off with nearly flat tops near their upper limit. Many small knobs rise above the wider levels. As a rule the flatter hilltops correspond with the tops of sandstone beds and the "potato-hill" knobs above them are remnants of higher levels in shale.

The main line of the Buffalo, Rochester & Pittsburgh Railway follows Mahoning Creek along all the south edge of the district. The Pennsylvania & Northwestern Division of the Pennsylvania Railroad is in the valley of Mahoning Creek from Canoe Creek to the west edge of the quadrangle. Railroad branches extend up Sawmill, Elk, and Big Runs, to the mines on those runs. This has been the largest mining district in the quadrangle, and one of the largest in the State. Large mines were located around Walston, Adrian, Anita, and Eleanora. Coke making and iron making are among the industries of the district. Punxsutawney occupies the broad valley of Mahoning Creek on the southwest edge of the district.

Stratigraphy.

The outcropping rocks of this district belong to the lower half of the Conemaugh group and the upper half of the Allegheny group. About 450 feet of the Conemaugh rocks still remain in place. The Allegheny outcrops only in the valleys in the northwest corner of the quadrangle, about 150 to 200 feet of the formation coming to daylight.

Conemaugh group. Though many sections of the Conemaugh group were obtained in this district, little regularity could be discovered. The lower 150 to 200 feet of the group are generally shaly. The massive sandstone in the upper part of the Mahoning formation is not prominent in this area; the lower part of the Mahoning formation is shaly in the western part of the area, but usually contains sandstone toward the northeast. Above the position of the Brush Creek coal are

the shales exposed in the cuts about Punxsutawney. From 150 to 200 feet above the base of the Conemaugh is a thick sandstone locally reported as more than 100 feet thick. Limestones occur at a number of horizons, especially within the first hundred feet above the E coal, and also at about 315 feet above the E coal. A few sections show limestone about 225 feet above the E coal. It is not certain that the lower limestone mentioned is always at the same horizon. In places it certainly comes just below the position of the Mahoning coal, and it is possible that all of it comes there, though the interval above the E coal varies from 40 to 80 feet. It is thought the upper limestone may be the Ames. Red shales were seen in a few places, but at so few as hardly to suggest any regularity.

Coals of workable thickness were not found in the Conemaugh rocks, 20 inches being the maximum. Most of the sections show little or no coal, and most of the beds found were not more than 8 inches thick. In one section five thin streaks of coal occur. The coal at the Brush Creek horizon is the one most often seen, but even it is absent in four-fifths of the sections and drill holes. Coal was seen so infrequently as to be difficult of correlation.

Allegheny group. Little is known of the Allegheny group except of the Freeport formation, containing the two Freeport coals. Both coals are workable locally and both are thin or wanting locally. Although most of the E coal in this district is thin and in places lacking, the D coal has a good thickness over large areas, and has been extensively mined. The two coals are from 38 to 70 feet apart, though averaging about 40 feet. The interval is predominantly sandy in about half of the sections and shaly in about half. The Upper Freeport limestone is contained in most of the sections but in some is thin or wanting, in others 15 to 25 feet thick. The rocks below the D coal, as far as seen, are mostly shale with a few thin beds of sandstone. The B coal lies about 200 feet below the E coal and the C coal about 130 feet; thin coals above the C coal may represent the C′ coal.

Structure.

The structure, or elevation and position, of the various rocks and and coal beds in this district has been determined with much accuracy through the extensive mining operations carried on here. The rocks dip steeply from the northwest corner of the quadrangle toward Punxsutawney, to the axis of the Punxsutawney syncline. In a distance of 3½ miles the E coal descends from an elevation of 1700 feet above sea level to 1150 feet at Puxsutawney, or nearly 200 feet per mile. Northeast of Punxsutawney the dip is less steep and less regular.

As a result of this dip the E coal, which is in the top of the hills in the northwest corner of the quadrangle descends and passes under Elk Run above Harmony and under Sawmill Run at Walston, so that it is 100 feet below Mahoning Creek at Punxsutawney. The lowest part of the syncline appears to extend northeast from Punxsutawney to a point one mile northwest of the town of Big Run, and then more to the north so as to lie close to Eleanora shaft. The structure contours shown on the map (Plate III) are on the E coal. The D coal, which is the coal being worked in this district, is found from 40 to 50 feet lower, and the B, which is entirely below drainage, some 200 feet lower.

Coal beds.

The uppermost coal beds of the Allegheny group of this district, the E and D, are well known. The other beds are little known. The two beds mentioned are both exposed in many places, and have been pierced by the drill in many other places, and the latter has been extensively mined. Under the D coal are four or more coal beds, of which only one, the B, gives any promise of being thick enough to mine.

E coal. As indicated in figure 7, sections 1 - 7, and 9, this coal is variable, ranging from 4 feet thick to a feather edge within short horizontal distances. Apparently the coal is lacking over considerable parts of the district, and pockety over the rest of the district. No systematic arrangement of the pockets could be discovered from the data at hand. From observations in other districts, it is suspected that the varying thickness may be due to the top or all of the coal bed having been eroded before the overlying rocks were laid down. The irregular thickness of the E coal can be clearly seen along Allegheny River south of Freeport, not far to the west of this quadrangle. Whether erosion caused the irregular thickness of the E coal near Punxsutawney is questioned from the fact that some of the thinner coal has a shale roof and not a sandstone roof as the thinner coal on Allegheny River and elsewhere have. The supposition that the thinning of this bed is in part due to subsequent erosion, is strengthened by knowledge of an eroded channel in this district which cuts out the D coal. Mining in the E bed in this district should be preceded by close and careful prospecting. If the thinning is due to erosion it may be possible to trace old stream channels, and learn, with some degree of accuracy, just where the coal has been cut out.

The sections (figure 7) show most of this coal to be without partings, though partings are present in places. In many sections the coal is overlain by several inches of bony coal. Generally the roof of the coal is shale, overlain by a sandstone that locally comes down

upon the coal. The floor of the coal is generally clay. No detailed study of this coal was made in this district.

D coal. The D coal is about 40 feet below the E coal at the Elk Run shaft, at the Eleanora shaft, and around Adrian. According to drilling records the distance between these coals ranges from 30 to 70 feet.

Though subject to considerable variations the D coal maintains a thickness of 6 feet or more in much of this district (see figure 9, sections 67 to 75 inclusive). Locally the thickness increases to 10 feet or more. On the other hand at some time following the deposition of this coal bed the land was elevated and channels were eroded in what was then the surface of the ground. Where these channels cut into the newly deposited coal, they partly or wholly remove it. The western edge of such a channel is encountered in this district following a north and south direction in the road fork 2½ miles due east of Anita and about ⅛ mile north of the McCalmont township line. A short distance north of this quadrangle a drainage tunnel was driven through the sandstone that filled this old erosion valley. Before driving the tunnel, a line of drill holes several hundred feet apart was put down, which found coal at every hole. It is said that when the tunnel or entry was driven it entered rock soon after passing one of the drill holes, and remained in rock until the next drill hole was reached which was then found to have penetrated a block of coal no larger than a room. Beyond this hole the tunnel was in rock almost all the way to the next drill hole. The writer has not examined this rock "fault." It is reported that both the D and the E coals suffer to the northwest of this area from the existence of rock "faults," apparently the sandstone filling of channels eroded soon after the laying down of the coal beds.

The D coal has no regular partings but any one section will show one or more streaks of "mother" coal or shale and commonly a few inches of bony coal at the top.

Normally the roof of the D coal in this district is shale, except where a sandstone "roll," such as those described, comes down upon or into the coal. The roof is generally strong enough to allow the use of machines in mining, though not everywhere. The floor is normally clay.

Distribution of resources.

The distribution of the coal and other economic minerals will next be described, beginning at the southwest corner of the district. Where Mahoning Creek leaves the quadrangle all the Allegheny coals are below water level. The E coal has only a slight depth. The

Mahoning limestone, which is about 50 feet above the E coal, outcrops in the bed of Mahoning Creek north of Lindsey. This black limestone is overlain by one foot of sandstone and that by 6 feet of clay with iron concretions. Above the clay are limestone and some iron ore, in all 12 feet[3]. This is the ore and limestone that analyzed 21.10 per cent of iron. The same ore shows again about a quarter of a mile below the bridge, more sandy than above, and is still poorer at the bend of the creek (Sliding Rock Bend). The irregularly bedded, yellow and brown Upper Mahoning sandstone is exposed in the railroad cut at Lindsey station. The upper surface of the sandstone suggests an unconformity or fault, as it lies abruptly against the overlying shales, the surface of contact having a pitch of 28° and strike of S. 50° E. The fact that no strikes are seen on the sandstone face and that the shales at the contact are not noticeably disturbed, favor the idea of unconformity rather than a fault. That kind of unconformity, however, is very rare in the coal measures, and here, if it be an unconformity, erosion has been followed by the deposition of shale rather than the usual sandstone. This shale in the lower part of the Buffalo formation is 60 to 80 feet thick at the Buffalo, Rochester & Pittsburgh Railway bridge just to the east. The broad valley in which the town of Punxsutawney lies has been eroded out of these shales.

The lower end of Sawmill Run is cut in lower Conemaugh rocks which form the hills on both sides. At the fan house (Ab 12) the D coal is 70 feet deep. The E coal is lacking in places in this part of the district though it is of workable thickness on upper Sawmill Run and its position there is usually marked by a distinct bench. The D coal rises to outcrop at the forks of the creek and is exposed under the schoolhouse (Aa 26) at the lower end of Walston. At the Walston No. 3 mine (Aa 25), the drift mouth is 30 feet above the outcrop of the D coal which is being worked here. The coal is 5 to 6 feet thick, not including 18 inches of shaly coal at the top. It ranges from 4 to 8 feet in thickness with an average of about 5½ feet. The roof over the shaly coal is sandstone and the floor is clay, 3 to 4 feet thick. Diagonally across the run is the opening of the Walston No.1 mine (Aa 24), which is about 12 feet higher than that at the No. 3 mine. Over the coal, which is here 6 feet thick, is from 0 to 4 feet of shale, then sandstone. In places the sandstone fills the depressions in an erosion surface and replaces part or all of the coal. Locally the coal is 10 feet thick. Four feet of clay underlies the coal. The D coal contains knife-edges of shale and, in places, wedges and irregular masses of pyrite, but not in such quantity as seriously to damage the bed. The dip is 3°to 4° to the southeast. These mines were nearly

[3]Pennsylvania Second Geol. Survey, Report H, p. 183, 1875.

worked out in 1905. The coal from No. 1 mine was used principally in supplying a line of coke ovens, 657 in number, which extended from No. 1 mine along the west side of Sawmill Run to Clayville, a distance of about 1½ miles. It was said at the time (1905) to be the longest line of coke ovens in the United States. (See Pl. III).

The E coal at this point is 2 feet 10 inches thick. Farther up Sawmill Run and 60 feet higher than the No. 3 mine was the Dewey mine, nearly worked out when examined. Still farther up are openings on the F. S. Hagg place. The coal is 5 feet thick or more, with a maximum of 6 feet 8 inches and is overlain by 8 inches of bony coal. Clay rolls cut the coal out in places in these openings.

On the ridge between Sawmill Run and Elk Run are many outcrops of the Mahoning coals. Where the ridge road crosses the north boundary of Punxsutawney borough (Ab 1) is an outcrop of the Harlem coal. The coal lies between shale and sandstone and is 4 inches thick. The Bakerstown coal outcrops with a thickness of 18 inches in a ravine on the Hagg place (Aa 27) one mile north of Punxsutawney. On the ridge north of Walston the dip makes the Brush Creek coal outcrop at various levels on the same hill (Aa 15), (Aa 18), (Aa 13).

As Mahoning Creek follows the axis of the Punxsutawney syncline from Saw Mill Run to the mouth of Elk Run, the E coal is 100 to 125 feet beneath Punxsutawney. The D coal is 140 to 175 feet deep. A short distance up Elk Run is the Elk Run shaft, which handles all the water from the mines to the north, except in emergency, when the reserve pumps at the upper mines are operated. At this shaft (Ab2) it is 120 feet to the E coal and 160 feet to the Lower Freeport, or D. The E coal here is 3 feet 4 inches thick and the D up to 5 feet 7 inches thick. Coal from this mine is raised through the Adrian No. 1 mine. The rise to the north brings the coals to daylight near the junction of Elk and Little Elk Runs.

At Adrian No. 1 mine the E coal is 30 feet above drainage and the D bed 43 feet lower. In 1905 this was one of the large mines of the district, and had a yearly production of about 1,000,000 tons. In 1924 this mine produced 1200 tons daily.

The D coal, which is being worked here, is from 4 feet 8 inches to 7 feet thick, averaging about 6 feet. Usually 6 inches of bone lies between the coal and the shale roof. The coal carries a persistent binder one-half inch to two inches thick. On the east side of this mine the coal is cut out along a wide belt by a channel filled with sandstone. The coke ovens at Adrian make a double bank a mile long. For years about one-half of the output of the mine (all passing a 6 inch mesh screen) went to the ovens. When the ovens were burning, 30,000 tons of coal made about 20,000 tons of coke, the monthly

output. The ovens have been idle for several years. At Anita on the north edge of the map are the Florence mines, also on the D coal. The Florence, Adrian, and Elk Run mines are all connected by underground workings.

The E coal has been opened at a number of points on the west side of Elk Run and on Little Elk Run. At the Conrad mine (Aa 11) opposite Adrian the D coal is 5½ feet thick and the E coal shows 4½ feet of rusty and impure coal overlain by 18 inches of bone. Over the E coal is the Lower Mahoning sandstone 40 feet thick. The lower surface of the sandstone roof is irregular, owing to the irregular thickness of the coal. The same coal up Little Elk Run presents much the same section and appearance, having a thickness three-quarters of a mile west of the mouth of Little Elk Run (Aa 17) of 4½ feet with 9 inches of bony coal between the coal and the sandstone roof.

The rise of the rocks to the northwest carries both coals rapidly out of the valley and up the hill slopes. At the Weber mine one mile west of Adrian (Aa 9) the D coal 4 feet thick is overlain by 4 to 8 inches of bone and that by sandstone. At the J. W. Brown mine (Aa 5) near Anita the D coal is 5½ feet thick, overlain by shale and underlain by clay. At the David Staley mine (Aa 6) the same bed is 5½ feet thick with 9 inches of bone between the coal and sandstone roof. The E coal, 4 feet thick, lies 30 feet higher. Toward the head of Little Elk Run in the northwest corner of the quadrangle both coals are almost to the top of the hills, and the Kittanning coals should be found in outcrop in the valley of Little Elk Run.

The high land between Elk Run and Big Run is formed almost entirely of rocks of the Conemaugh group. The E and D coals, which outcrop around Adrian and to the north, descend to the east and south with a pitch of 2 to 3 degrees and are entirely below drainage in that direction. A few outcrops of the Conemaugh coals are found along the roads and the Ames limestone has been found at many points, as on the east side of Windfall Run (Da 1). A section of this limestone was given on a previous page.

Mahoning Creek runs in Conemaugh rocks all the way from the northeastern edge of the quadrangle to Punxsutawney. At the mouths of Canoe Creek and of East Branch it just about touches the top of the Allegheny group or E coal. The Mahoning clay and limestone are exposed in a cut at Williams flag station, as described on page 25. Big Run Valley is in Conemaugh rocks to the north side of the quadrangle. Near the edge of the quadrangle close to Big Run is the Eleanora shaft (Ca 1) which reaches the D coal at a depth of 269 feet, or at an elevation of 1055 feet above sea level. This is near the bottom of the syncline. The coal is 10 feet thick, not including a 2-foot rider overlying 2 feet of shale. The roof is sandstone and shale. Forty

feet above is the E coal, 4 feet 3 inches thick. These coals are deep below the surface east of Big Run. The E coal barely rises to outcrop at the mouth of East Branch.

LOCUST DISTRICT.

Introductory statement.

The Locust district comprises the area west of the Indiana branch of the Buffalo, Rochester & Pittsburgh Railway: that is, south of Mahoning Creek at Punxsutawney, west of Canoe Creek from Cloe post office to Locust, west of Broadhead Run from Locust to Richmond. The area is an entire contrast with the Punxsutawney area, for while that district is rich in coal and contains several large mines and accompanying industries, the Locust district appears to contain little coal, and has no large mine. On the other hand, a gas field has been found near the center of the district. The Indiana branch of the Buffalo, Rochester & Pittsburgh Railway runs almost all the way around the district following the valleys of Mahoning and Canoe creeks, Broadhead Run, and Little Mahoning Creek. Canoe Creek cuts the district in two in the middle, and serves as a channel for the Buffalo and Susquehanna Railroad from Juneau to the Plum Creek mines.

Stratigraphy of outcropping rocks.

The surface rocks of this district are of Conemaugh age, except a few feet of Allegheny rocks just above the flood plain of Canoe Creek, and around the south end of the district along Broadhead Run and Little Mahoning Creek. A maximum of probably 420 feet of Conemaugh rocks remains. These are very largely shale, as revealed both in the natural exposures and in drill holes. The lower part of the Mahoning formation is not well exposed in the area immediately south of Punxsutawney. It appears to consist almost entirely of shale, some of which is flinty. At the horizon of the Mahoning coal is a little black shale, beneath which are limestone and a little iron ore. The upper part of the Mahoning formation consists mainly of sandstone. It is prominently exposed above the station at Lindsey, and is pierced by wells in the lower part of that town. Ten to fifteen feet above the top of the sandstone is the Brush Creek coal. This is 7 inches thick in a railway cut near Horatio. It outcrops on both sides of Painter Run, where in one exposure, the coal is in two benches, the upper 5 inches thick and the lower 13 inches, with 6 inches of shale between them.

Above this coal is the Buffalo formation, consisting of 70 to 90 feet of shale, the top of which is about 165 feet above the E coal. The shale is overlain by the Buffalo sandstone which is massive in a few limited areas. At the top of the formation and about 200 feet above the E coal, are red shales and one or two thin bands of limestone, probably the Pine Creek, then the Bakerstown coal at about 230 feet above the E coal. The Bakerstown coal outcrops at the top of the hill in the road from Punxsutawney to Cloe and at the top of the hill above Finley Mills on the road to Punxsutawney, and has been dug into south of Painter Run near the Punxsutawney-Juneau road. At an estimated elevation of 310 feet above the E coal, a thin but persistent coal outcrops at many points beside the roads in the tops of the hills 1 to 4 miles southwest of Punxsutawney. This may be the Harlem coal. A limestone, supposed to be the Ames, about 325 feet above the E coal, is exposed on the western edge of the quadrangle just north of the Indiana County line. The E coal outcrops along Canoe Creek from Juneau to Cloe. The coal is 2 to 3 feet thick, and is underlain by 50 feet of olive sandy shale and sandstone. According to some drill records the E and all of the other Allegheny coals are absent in the middle of the Locust district, except a 2-foot bed about in the position of the B coal.

Stratigraphy of rocks not exposed.

A number of deep wells have been drilled for gas in the area just northwest of Juneau (see figure 4). Some of these go to a depth of 2,700 feet, or 1,300 feet below sea level, and reach well down into the Devonian rocks. The records of these wells do not give details, but indicate the predominant character of the rocks. In the records of some of these wells the Allegheny group is represented as all sandstone, in some as all shale, but in more as partly sandstone and partly shale. The Pottsville appears to be generally represented by shale. All the records show sandstone which ranges from 150 to 250 feet thick in the different wells. This probably correlates with the "Big Injun" sand or Burgoon sandstone of the Pocono series of Mississippian age. Apparently the Mauch Chunk series is absent in this region. Below the "Big Injun" sand are 300 to 400 feet of shales, most of which are red, and below these occur two sandstones which may correspond with the Berea sand and the Murrysville sand. The former has proved gas bearing. Below that the wells pierce about 1500 feet of Devonian rocks, and reach a gas-bearing sand at that depth, as already described under the general head of Stratigraphy.

Structure.

The structure is very obscure in all but the south part of this district. All the outcropping rocks, except a narrow strip along Canoe Creek from Juneau to Canoe Creek station, and around the south end of the district are of Conemaugh age. Furthermore the apparent absence of nearly all the Allegheny coals in wells in the northern part of the district makes it difficult to determine definitely the stratigraphic position of the few Conemaugh coals that outcrop. In certain small areas outcrops of what was thought to be one bed of coal in the Conemaugh group gave definiteness to the structure in those small areas.

The road over the hill south of Punxsutawney to Juneau appears to be in the shales immediately above the Brush Creek coal all of the way to Painter Run, indicating a rise almost equal to the slope of the hill. Continuing south of Painter Run for one mile, the structure appears to be flat or slightly anticlinal. Then the rocks appear to dip into a syncline under Canoe Creek.

The logs of the wells in the Juneau gas field indicate a slight syncline north and west of Juneau and a low anticline west of that, though these do not show clearly at the surface. From Locust Lane there is a sharp rise of the strata to the south, so that the E coal, estimated to be 1250 feet above sea level north and northwest of Locust Lane, is 1600 feet above sea level at Richmond.

Distribution of resources.

In the northwest corner of the Locust district, where Mahoning Creek leaves the quadrangle, the strata dip to the center of the Punxsutawney syncline. The exposures about Lindsey have already been mentioned. From Lindsey east, railroad cuts expose the shales above the Brush Creek coal to within a mile of the mouth of Canoe Creek, where, the syncline having been crossed, the top of the Upper Mahoning sandstone reaches outcrop. The E coal rises to outcrop at the mouth of Canoe Creek and is level with the track of the Buffalo, Rochester & Pittsburgh Railway. The same coal shows at many points along the railroad up Canoe Creek.

The road running southeast from Punxsutawney toward Juneau is in the shales of the Buffalo formation almost all the way to Painter Run. There on both sides of the run, at about 1390 feet, the Brush Creek coal outcrops (Ab 9 and Ac 3). The massive Upper Mahoning sandstone is exposed immediately below these outcrops. Although quite massive at this point it becomes softer and less resistant up and down stream.

The road running southwest from Punxsutawney over the hill keeps more nearly along the axis of the syncline and reaches what is thought to be the Harlem coal 300 to 310 feet above the E coal This bed outcrops at a number of points along the crest of the hill, having a thickness at one point of 9 inches (Ab 4- 5- 6- 8), (Ac 1). The "lower red shales," just below the position of the Bakerstown coal, show plainly on all of the roads ascending to this hilltop. Locally limestone fragments, possibly the Pine Creek, are to be found in connection with the red shales, as at the edge of the quadrangle two miles southwest of Punxsutawney (Ab 7). Just east of where the hill road crosses the west line of the quadrangle, fragments of limestone were found, probably representing the Ames, at about 325 feet above the E coal (Ac 2). The Bakerstown coal shows at the top of the hill on the road from Punxsutawney to Cloe post office (Bb 1 and 2); and an attempt has been made to work it west of Painter Run near the road (Ac 10). The outcrop of red shale and limestone three-quarters of a mile northwest of Juneau (Ac 5) is thought to be just below the horizon of the Bakerstown coal. If that interpretation is correct the massive sandstone debris on the face of the hill northeast of Juneau comes from the Buffalo sandstone. This sandstone does not maintain its massive character for any distance to the north. Most of the district north of the Buffalo and Susquehanna railroad shows only shale and small fragments of shaly sandstone. The structure is clear in the northeast corner of the district, but elsewhere it is obscure, so that the correlations suggested are for the most part tentative. The Brush Creek coal outcrops just west of Cloe Post Office, at Bb 3. The black shale at the horizon of the Mahoning coal shows in the road fork just north of Juneau (Ac 6 and 7) and elsewhere. It was this bed that was formerly confused with the E coal.

The E coal outcrops in the hill all along the west side of Canoe Creek from the Buffalo, Rochester and Pittsburgh trestle above Cloe Post Office nearly to Juneau. Opposite the mouth of Ugly Run (Bb7) the coal is 2 feet thick, overlain by 20 feet of shale, and underlain by 3 feet 6 inches of good clay. Farther south the same coal outcrops (Bb 8 and 9), and it has been dug a little at road level one mile below Juneau (Bc 1). The coal here is 3 feet 6 inches thick with 8 inches of bone on top. The lower Mahoning sandstone 20 feet thick makes the roof. The mine of the Juneau Coal Mining Company is said to show a rolly roof that makes the coal irregular in thickness, cutting it down locally to 1 foot.

Apparently the hill northwest of Locust Lane contains about as great a thickness of Conemaugh rocks as the hills in the north part of the district. If correctly correlated the limestone near the top of the hill (Ad 1) is the Ames, and the coal found north and northeast of

this is at the Bakerstown horizon (Ac 8 and 9). The shales above the Brush Creek coal show well in the deep cut at Locust Lane.

One mile south of Locust Lane the southeastward rise of the rocks brings up the Freeport coals, the E outcropping at Ad 3. The coal has been opened in a small way here and on Hess Run (Ad 4, 5 and 6). At the mine one mile south of Locust Lane (Ad 4) the coal varies from 3 to 4 feet in thickness within short distances, in one place within a space of 50 feet. Where it has the greater thickness it contains bony streaks. Between the shale roof and the coal is 6 inches of dark shale, grading into bone. Under the coal are two feet of light-drab clay, then eight inches of coal with clay below. On the east side of Hess Run (Ad 5) the coal is 4 feet 1½ inches thick, and overlain by 5 inches of bone, with sandy shale above. The E coal at the Hess mine on Hess Run (Ad 6) is reported as 4 feet thick with 8 inches of bone above overlain by sandstone which makes the roof. The bed is said to be irregular in thickness.

A few openings have been made on the coals on Leasure Run but all had fallen shut when visited. In the head of the run ⅝ mile north of Savan the Upper Freeport limestone, 2 feet 6 inches or more thick, is exposed (Ae 1). Coal in this hollow has been dug into on the Pifer Place (Ae 2).

The rise of the strata to the southeast brings up the massive Clarion sandstone at the junction of Broadhead and Hess runs and the sandstone is exposed extensively by the railroad cuts north and northeast of Richmond. Just across Little Mahoning Creek to the northwest of Richmond is an outcrop of the B coal 4 feet 2 inches to 5 feet thick in two benches, the upper 2 feet to 2 feet 2 inches thick and the lower 18 inches to 1 foot 11 inches thick, separated by a 1½-inch parting. Below the coal, in order, are: 2 feet of brown sandy clay, 10 feet of gray to light-drab sandstone, 6 feet of gray sandstone (ganister with stems), then 2 feet to 18 inches of light-drab sandy flint clay. Assuming the correctness of the correlation of this coal as the B, this flint clay is at the same horizon as the flint clay so abundant at Clarion.

WINSLOW DISTRICT

Introductory statement.

The Winslow district includes the land south of Mahoning Creek, east and north of Canoe Creek and Ugly Run, and west of Clover Run and Stony Run. It is a high upland with a nearly flat top, broken by deep ravines around the edges. Winslow post office is in the south-central part of the area. The flat land around Winslow

has an elevation of about 1760 feet. In the southeast corner of the district a few acres at the head of Stony Run are at an elevation of 2,000 feet. Mahoning Creek is 1,250 to 1,300 feet above sea level.

The Buffalo, Rochester & Pittsburgh Railway follows along the northern edge of the district and part of the western edge, and the Pennsylvania and Northwestern division of the Pennsylvania Railroad follows the southern edge, so that every part of the district is within a few miles of railroad transportation, with down grade from any point to the main lines of the railroads. Two or three small commercial mines are producing coal in the northern part of the district and as many more in the southern part.

Stratigraphy.

The rocks exposed over most of the Winslow district are of Conemaugh age though rocks of Allegheny age outcrop in the valley of Ugly Run and in Clover and Stony Run valleys. Except in the northwest part of the district adjoining Mahoning Creek, the thickness of the Conemaugh rocks in most of the hills is but little over 100 feet. A massive sandstone in the Upper Mahoning dominates the area, and is the cause of the flat hilltops. The debris from its outcrops around the edge of the district to the east and south tends to hide all other formations. The top of this sandstone is, as a rule, 100 to 110 feet above the top of the Allegheny group or the E coal. In the northwest part of the district from 50 to 100 additional feet of Conemaugh rocks occur, consisting largely of shales of the Buffalo formation with some heavy sandstone. Between the Upper Mahoning sandstone and the E coal is mostly olive shale, in places flinty. Coal was not seen at the horizon of the Mahoning coal. Coal blooms were seen in the position of the Brush Creek coal, which was reported to have a thickness of 2 feet near Hudson.

Little is known of the stratigraphy of the Allegheny group, as it outcrops only in the sloping sides of the valleys of Clover and Stony runs on the east and Ugly Run on the south. The E coal, which ranges from 3 to 5 feet thick, is the dominant coal of the district, and was the only coal mined when the field work was in progress. The D coal underlies the E at a depth of about 40 feet, the intermediate strata being the clay underlying the E coal, the Upper Freeport limestone, usually some shale and then a more or less massive sandstone. Under the D coal are found the C'_2, C, and B coals, though as these beds are not being mined, scant data were gotten upon their thickness or quality. The few sections obtained in this region indicate that the Allegheny group is principally shale. The records of drill holes in this region indicate that the D coal is irregular, and though the E coal

is generally found in place, in many of the sections it appears to have been removed or not deposited. The intervals between the coals vary widely, so that it is difficult to give any generalized section.

Structure.

The structure or lay of the rocks in the Winslow district is nearly as well determined as in the Punxsutawney district, partly from the openings on the E coal, which is the coal principally worked in this district, and partly from the top of the massive Upper Mahoning sandstone which is 100 to 110 feet above the top of the E coal. The rocks show a steep rise from Mahoning Creek southeastward. At Bells Mills on Mahoning Creek the E coal has an elevation above sea level of about 1150 feet, and at Hillman, or North Summit, the same bed is 1950 feet above sea level, a total rise of 800 feet in about 5 miles, or 160 feet to the mile. At Hudson the E coal is between 1550 and 1600 feet; at Winslow between 1600 and 1650 feet above sea level. The E coal underlies practically all the district except the eastern edge, where it outcrops high in the escarpment facing Clover Run and Stony Run. It also outcrops along Ugly Run at the south. The dip from Hillman to Canoe Creek appears to be fairly uniform but doubtless more data would reveal a greater variation than is shown. From Hillman to Winslow Station, from Rossiter Junction to Canoe Creek, and southeast of the town of Big Run, the dip has been determined from the position of the E coal. Over the rest of the district the dip has been determined from the elevation of the top of the massive Upper Mahoning sandstone, which, as stated, has been assumed to be 100 to 110 feet above the E coal. In the area between Canoe Creek and Big Run there is uncertainty as to whether the first coal of workable thickness in some of the drill holes is the E or the D. This is in the area in which the D coal is losing in importance going southward and the E coal is gaining in the same direction, so that in many of the drillings both coals appear to be irregular and in some one or both of these coals are thin or wanting.

Distribution of resources.

The Allegheny coals are below drainage all along Mahoning Creek and the northwest side of the district at the mouths of Canoe Creek and the East Branch. They rise to the southeast with the hill, keeping under slight cover until they outcrop to the east and south. The Upper Mahoning sandstone outcrops in the steep slope on the east side of Canoe Creek at about 1350 feet above sea level and rises sharp-

ly to the eastward. The road from Cloe post office to Winslow post office, after passing an outcrop of the Brush Creek coal (Bb 11), climbs over a hill that is capped by the Buffalo sandstone overlying the shales of the Buffalo formation. The top of the Upper Mahoning sandstone is met again where the road comes down to the run one mile east of Cloe, and the top of that sandstone keeps just under the road as it climbs the next hill to Winslow post office and beyond.

Conditions are more or less similar on the roads southeast from Bells Mills and south from Big Run to the upland. The Mahoning sandstone makes a steep escarpment with local cliffs along the edge of the upland above Ugly Run and Clover Run, and the valley sides are strewn with sandstone blocks. The hills in the northeast part of the districts are carved in the shales of the Buffalo formation.

The Buffalo and Susquehanna No. 3 mine was opened in 1904 between Bells Mills and Big Run. The shaft encounters the Brush Creek coal 2 feet thick at 70 feet and the E coal at 154 feet. The E coal varies from 3 feet thick on the right side of the mine to 6 feet on the left, averaging about 4 feet, with a 1 to 3-inch binder 8 inches from the floor. Over the coal is 2 feet of bone. Above that is shale on the right and sandstone on the left side of the mine. This mine encounters faulting, as do most of the other mines of the district.

The E coal outcrops around a small area in the valley of the run that enters Mahoning Creek opposite the town of Big Run. The Big Run No. 1 mine (Db 1) was opened in 1905. The E coal is here 4 feet thick, though thinning to nothing locally. It carries a binder 4 to 8 inches from the bottom. The roof is shale and the floor clay. At one place in the main heading the coal thins down to 8 inches. The D coal is reported to lie 30 feet below and to be 4 feet thick. The E coal is above the drainage over a small area (Da 3) three-quarters of a mile south of the mouth of East Branch. The Upper Freeport limestone shows at the same point.

The E coal outcrops about at water level at the mouth of East Branch. It rises along the west bank of the run and reaches an elevation of 1380 feet above sea level at the Frank P. Brown bank (Da 4). Here the coal is 2 feet 5 inches thick with a 1-inch binder of bone 4 inches from the bottom. Over the coal is from 4 to 6 inches of bone with shale above, and below is a clay floor. At the Andy McClure and Dean McConne bank the E coal is 3 feet thick, overlain with sandstone and underlain with sandy clay. The elevation of the coal here is about 1490 feet (Da 5). The coal on the west side of Clover Run continues to rise to the south, keeping about 100 feet below the top of the sandstone that forms the escarpment, until at the head of Stony Run the bed lies under the top of the divide and outcrops on the south side of the ridge above Ugly Run 1950 feet above sea level.

A little over a mile east of Winslow Station the E coal is being worked at the Hillman mine by the Bower Brothers (Db 5). The coal is 3 feet 6 inches to 4 feet thick with a 1-inch binder 10 inches from the bottom. The roof is a drab clay shale with 10 inches of draw slate and the floor is clay. The D coal is reported to be 58 feet below the E and to be 6 feet thick with an 8-inch binder 14 inches from the bottom; and the B coal is reported in place 180 feet below the E. The north slope of Ugly Run is covered with blocks from the Upper Mahoning sandstone which outcrops at the top of the escarpment. The top of the sandstone makes a nearly uniform elevation of about 130 feet above the railroad. In the same area the E coal is within 20 feet above the railroad from the Hillman mine to and beyond Winslow Station. It is well exposed in the first cut west of Winslow, where it is only one foot thick. The roof is sandy shale. Below the coal is 2 feet of clay, then 2 feet of limestone, with clay shales and sandstone below that. Westward from this cut the coal bed does not descend as much as the railroad and the railroad cuts are made in the Freeport sandstone which is between the Upper and Lower Freeport coals.

Less than a mile below Winslow the E coal is 50 feet above the track and is being worked by the Hamrock Coal Company. The coal in their Cherry Grove mine is 3 feet 4 inches thick, including 1 to 2 inches of shale 2 inches from the bottom. The coal at the Cherry Grove mine is somewhat irregular in thickness, thinning down to 2 feet in the main heading, as a result of irregularities in the shale roof, or of erosion in early Mahoning time as indicated by the irregular surface between the shale roof and overlying shaly sandstone which usually is less than 10 feet above the coal. Below the coal are 2 feet of sandy clay, then sandstone. The D bed, reported to range from 18 inches to 5 feet in thickness, outcrops just above the railroad track. Below the Cherry Grove mine the railroad more nearly follows the dip so that at Rossiter Junction the E is again less than 20 feet above the track. Where the Pennsylvania and Northwestern crosses under the Buffalo, Rochester & Pittsburgh Railway, the E coal is about 30 feet above the tracks of the former. Beyond this point the dip carries the coal rapidly to the creek level.

ROSSITER DISTRICT

Introductory statement.

The Rossiter district comprises the area east of the Indiana branch of the Buffalo, Rochester & Pittsburgh Railway from Richmond to Rossiter Junction, south of the Pennsylvania and Northwestern division of the Pennsylvania Railroad from Rossiter Junction to North Summit, west of a line from North Summit following the roads

through Flora to the head of Straight Run and down Straight Run to Robertsville, and north of Little Mahoning Creek between Robertsville and the mouth of Broadhead Run. Topographically the area consists of a high rolling upland in the east central part while the rest is irregular ridges and deep ravines. The area is surrounded by valleys on all sides, except beetween Flora and North Summit, allowing railroad transportation to the coals. The Pennsylvania and Northwestern, and the Indiana branch of the Buffalo, Rochester & Pittsburgh give transportation facilities to the north and west sides of the area; and a short branch of the New York Central railroad, leaving the Pennsylvania and Northwestern at Rossiter Junction, extends south to Rossiter and serves the large mines at that point. Rossiter is the only town in the area.

Stratigraphy.

The Rossiter district, as shown by the geologic map, is underlain about equally by rocks of the Conemaugh and Allegheny groups. The Allegheny group is not well exposed in the western part of the district, owing in general to a covering of debris from the Conemaugh sandstones. Considerable drilling has been done in the area.

Conemaugh group. Only the lower 200 to 250 feet of the Conemaugh group remains in this district. The Conemaugh sandstones are variable in position and extent. In some places sandstone lies directly on top of the Upper Freeport or E coal; in others the base of the lowest sandstone is 50 to 80 feet above the E coal, or there is no sandstone. In general, the lower part of the Conemaugh is more commonly shaly or sandy. The limestone underlying the Mahoning coal is present in a number of places, and in others its position is filled by sandstone. Over the limestone clay occurs locally and in some exposures a little coal. Sandstone occurs commonly in the upper part of the Mahoning member, that is, above the position of the Mahoning coal, but it does not occur there uniformly; shale may occur in that part of the section. Coal has been found 100 feet above the Upper Freeport or in the position of the Brush Creek coal. Above the coal the rocks vary, with a preponderance of shale. At one place a thin streak of coal occurs about 150 feet above the Upper Freeport.

Allegheny group. The top of the Allegheny group in this district is marked by the Upper Freeport or E coal, nearly or quite everywhere of workable thickness. Below the coal are a few feet of clay, and under that the Upper Freeport limestone. This limestone varies from one foot to a reported thickness in one or two places of 40 to 50 feet. It is 10 feet thick in some outcrops. The Lower Freeport or D coal occurs some 40 feet below the Upper Freeport, but, as far as known, in this district does not appear to be of good workable thickness.

Neither the Middle nor Upper Kittanning coal is being mined and both will probably be found too thin to be generally workable. The Lower Kittanning or B coal was not seen of workable thickness in this area, though it probably is workable over more or less of the district. No sections of the A coal were measured. A coarse-grained sandstone between the B and A coals is prominent on Little Mahoning Creek around Richmond and on the flanks of the gorge farther up that stream. In the southeast part of the area the whole thickness of the Allegheny group is exposed, from the valley of Little Mahoning Creek to the top of the hills.

Pottsville series. The Pottsville series is above water level in the gorge of Mahoning Creek above Richmond, but it is not well exposed. The Mississippian rocks do not outcrop in this district.

Structure.

The structure in this district is similar to that in the Winslow district. In general the rocks seem to have a fairly uniform rise to the south of east, the dip being rather gentle near the axes of the folds, but steep between Canoeridge and Rossiter. In that area the rocks rise more than 200 feet in one mile. The E coal, which has an elevation of 1300 feet above sea level north of Juneau, is between 1350 and 1400 at Rossiter, and at Winslow Station 1650 feet. At Canoeridge the same coal is between 1600 and 1650 feet. At Flora in the northeast corner of the district it reaches an elevation of 1900 feet. In this district the determination of the structure from the outcrops of the E coal is verified by the records of many drill holes.

Coal.

The E or Upper Freeport coal, is the dominant coal in this district. It was thought that all but one of the coal openings found were in this bed. Although the E coal is well known over the district, little is known of the lower beds.

E coal. The E coal in the Rossiter district is from 2 feet 6 inches to 7 feet thick, averaging about 4 feet 6 inches, the thickness increasing from the northwest to the southeast. In many of the sections the coal is without partings or binders; but a parting or binder from 1 to 3 inches thick is in places found from 6 to 9 inches from the bottom. Commonly the floor is clay, underlain within a few feet by limestone, but in a few places 3 or 4 inches of bone come between the clay and the main bed of coal. Usually the roof is black shale, in places lying directly on the coal, in others separated from the coal by 4 to 10 inches of bony, or a thin limestone. In a few places the black shale is reduced in thickness to 1 or 2 inches and overlain by a thick bed of sandstone.

D coal. Drill hole records indicate that in places in this district the D coal is absent; elsewhere it may be reported as streaks of coal in sandstone. One measurement gave 7 inches, another 2 feet 3 inches, still another 3 feet 8 inches. Near the south end of the district, a coal bed thought to be the D coal (Bd 9), is 2 feet 6 inches thick, underlain by 16 inches to 2 feet of coal that grades into bone. Below that is 3 feet of clay, then 1 inch to 1 foot of coal. On the whole this bed gives little promise of yielding much workable coal, though it will probably prove workable in some areas.

Other coals. A few measurements on the C′ coal gave thicknesses of 8 to 20 inches. On the C coal a single measurement gave 18 inches. On the B coal measurements gave a thickness of 12 to 21 inches or more. Near Enterprise a coal bloom 20 inches thick (Be1) was thought to be the Clarion, or A′ coal, coming below the B coal and above the top of the Clarion sandstone.

Distribution of resources.

The Rossiter district is economically dominated by the E coal, which underlies the northwestern two-thirds, and outcrops in a long line around most of the district. The hill between Ugly Run and the stream flowing past Rossiter has a body of E coal entirely detached from the adjoining areas. At the northwest that coal is only about 50 feet above creek level, overlain by rocks of the Conemaugh group, with a maximum thickness of hardly more than 200 feet. The coal rises southeastward, more than keeping pace with the rise of the hill, so that around Flora it underlies only the hilltops. There is also a detached area of E coal about one-half square mile in extent between two forks at the head of Ugly Run. Several openings have been made in this detached area, the coal being 42 inches thick at (Dc 3), though at the Bowers mine (Dc 6) just southwest of Hillman the coal is 4 feet 1 inch thick, including a 3-inch parting of shale 9 inches from the bottom. The top coal is rather shaly. The E coal has been mined near Rossiter. The coal was first opened at the J. C. Smith mine (Bc 1) north of Juneau, and later at the Frances No. 1 mine of Punxsutawney Coal Company (Bc 8). The coal is here about 1400 feet above sea level. It is about 4 feet thick, including 2 inches of bone 6 inches from the bottom, and lies between a shale roof and clay floor.

The main body of the coal, south of the isolated tract just described, is just about at creek level north of Juneau. From Juneau to Locust it is below drainage. Between Juneau and Rossiter there is a rise of about 100 feet, bringing the coal well above creek level around the latter place.

At Rossiter are the Canoe Ridge or Rossiter mines of the Clearfield Bituminous Coal Corporation. These mines have a daily capacity of 2800 to 3000 tons of coal. The coal in these mines is 3 feet 8 inches to 5 feet thick and has an average of 4 feet 6 inches. Along Canoe Creek the coal is 2 feet 4 inches to 3 feet thick but thickens to the southeast so that locally, south of Rossiter, it reaches a thickness of nearly or quite 7 feet. In the Gaston opening at Canoeridge (Bd 2) coal measured 5 feet 4 inches thick.

The E coal is below drainage around and to the north of Locust Lane but rises to outcrop a short distance south of Locust Station and in the north branch of Straight Creek a short distance west of Canoe Ridge store. From these points the rise from the southeast carries the coal rapidly up the hillside and into the hilltops. At the Joe Young and Miles Sigers's banks, two miles southeast of Rossiter, (Cc 2) (Cd 1) the coal is 4 feet thick and is 1800 feet above sea level, having risen 500 feet in 2¾ miles. It has the same elevation at the A. State's mine, where the coal is 5 feet thick, and underlain by the Upper Freeport limestone. In the southwest part of the district the E coal has been opened in a saddle of the hilltop (Ad 7) one-half mile northwest of Enterprise, and is mined by the Locust Colliery Company on Broadhead Run one mile below Locust (Ad 11) on the Buffalo, Rochester, & Pittsburgh Railway. The Locust No. 1 mine is at an elevation of 1425 feet. According to H. M. Kanarr Company, mining engineers, the coal in this mine is very rolly; but normally is 3 feet 6 inches thick and overlain by bone.

Coal blooms show at many points around the south and eastern sides of the district, but seldom reveal the thickness of the coal. Just north of Enterprise there are outcrops of both the B and A′ coals. The B (Ad 8) shows a thickness of 1 foot plus, and is underlain by 30 inches of clay and that in turn by a mixture of angular chunks of sandstone and flint clay. The A bed shows 20 inches of coal with a shale roof and clay floor. Along the south edge of the district the massive Clarion sandstone, often conglomeritic, is prominent at Enterprise and to the east along the gorge of Little Mahoning Creek.

RICHMOND DISTRICT

Introductory statement.

The Richmond district comprises the southwest corner of the quadrangle, including the area south of Little Mahoning Creek and west of Little Mahoning Creek and East Run. The creeks descend from 1540 feet at East Run to 1250 feet at Savan. The district as a whole is very hilly with almost no level ground or even sub-level, except small stretches of bottom land along Little Mahoning Creek and Crooked Run, and in the headwaters of Barrett Run, where a small

area is held up by the massive Clarion sandstone. In the center of the district is Kinter Hill, which rises to 2,068 feet above sea level. A large share of the district is almost or quite too steep for proper cultivation, though, as there are few heavy sandstones, except around Richmond, the surface is not as a rule covered with massive sandstone blocks. The more gentle slopes are cultivated. Richmond, or Rochester Mills post office is the principal town. The Buffalo, Rochester & Pittsburgh Railroad skirts the northwest corner of the district, and all other parts of the district could be put within easy reach of transportation by a railroad along Little Mahoning Creek. A branch of the New York Central and Hudson River Railroad touches the district at Ord and Robertsville.

Stratigraphy.

The rocks exposed in this district comprise about 200 feet of the Conemaugh group, all the Allegheny group, and a small amount of Pottsville exposed in the valley of Little Mahoning Creek above Enterprise. The hilltops are for the most part in Conemaugh rocks and the hillslopes in Allegheny strata. Most of the rocks outcropping in the district belong in the Allegheny.

In most of the hilltops not more than 100 feet of Conemaugh strata remain, but in the Kinter Hill Ridge and in the hill southwest of Savan there are at least 200 feet. In both of these places the highest rock is the Buffalo sandstone, the top of which is about 200 feet above the E coal. In both places this sandstone is more or less conglomeritic. The massive sandstone in the upper part of the Mahoning formation does not appear here as it does to the northeast in this quadrangle, though some sandstone occurs in that interval. In general this part of the section is more commonly shaly than sandy. The lower part of the Mahoning formation here as elsewhere over the quadrangle commonly is shale, and in several places contains yellow, flinty clay, or the shales themselves grade over into a flinty shale 10 to 50 feet above the Upper Freeport coal. Except for the Buffalo sandstone at the two places mentioned, the Conemaugh group of this region is mostly shale.

Allegheny group. The Allegheny group is fairly well exposed in the roads of the district, but, as there are no large mines and little drilling has been done, only a limited amount of data on the coal beds was obtained. The E coal has been opened at several places for mining in a small way and its position is probably well determined. At a number of points, where the coal does not show, its position was assumed from limestone fragments found at what was thought to be the horizon of the Upper Freeport limestone. From 35 to 50 feet below the E or Upper Freeport is the D or Lower Freeport. The

intervening strata consist mainly of shale and sandstone in about equal quantity, with the Upper Freeport limestone occurring generally within 15 feet below the E coal. This limestone appears to be only 2 to 4 feet thick but locally it seems to be somewhat thicker. The D coal is workable locally and has been opened in a small way at a number of places. From 80 to 100 feet below the E coal is the C′ coal which is unique in this district in being of good workable thickness, and in being overlain at one point by a lens of cannel coal. Near Richmond the C′ bed reaches a thickness of five feet or over. The interval between the D and C′ coals appears to consist mainly of shale, though usually containing at least one bed of sandstone 10 to 20 feet thick. From 180 to 200 feet below the E coal is the B coal which is, locally at least, of workable thickness. Between the C′ and the B coal are coal blooms indicating the position of the C coal, but at no point was a measurement obtainable. Most of the exposures noted of the interval between the C′ and B coals are shale, though in several a sandstone 10 to 15 feet thick appears at about the middle of the interval. The correlation of the B coal is indicated by the usual thickness of clay under it, which at several points south of Ord post office is 7 feet; and in the region west of Richmond by the presence below it of a limestone assumed to be the Vanport. This limestone is 30 feet below the coal. Between the coal and the limestone are first, the underclay of the coal, then in some places a little sandstone and locally some flint clay, corresponding to the Clarion flint clay; then blocky, light drab shale, to the limestone. This district is also interesting in that under the limestone is found a thin coal, apparently in the position of the A′ or one of the Clarion coals. This coal usually is within a few feet below the limestone and is from 7 to 20 inches in thickness. Below that is either shale or shaly sandstone 15 to 20 feet thick to the top of the massive conglomeratic sandstone upon which the town of Richmond is built. The top of this sandstone appears to be 40 to 70 feet below the B coal. From its nearness to the B coal it is assumed that this sandstone corresponds to the Clarion sandstone of the region to the northwest, rather than to the Homewood sandstone in the top of the Pottsville series. In places, a little coal has been found below the sandstone which, on the assumption of the sandstone being the Clarion, would be the A or Brookville coal.

Pottsville (Kanawha) series. The Pottsville series outcrops in the valley of Little Mahoning Creek from a point east of Richmond to the neighborhood of Ord post office. Probably the whole thickness of the formation is above the creek in the south bank of the valley just east of Enterprise. However, it is so completely covered by the massive debris from the Clarion sandstone that no sections of it were obtained. A few exposures in Beech and Barrett Runs reveal a thin-

bedded sandstone, such as would not be suitable for building purposes, or would not in itself tend to make cliffs or prominent escarpments. At one point a few inches of coal were seen in the position assumed to be at the horizon of the Mercer coal.

Structure.

A fork or spur of the Chestnut Ridge anticline crosses this district from northeast to southwest practically through the center. On the west side of this anticline the dip is quite sharp. The E coal rises from 1400 feet at Savan to 1850 feet above sea level northeast of Kinter Hill, a rise of 450 feet in less than two miles. This rise is very apparent on the road from Richmond to Nashville. The massive sandstone that underlies Richmond at 1300 feet keeps just under the road nearly to Beech Run. Here the road goes down into the sandstone and stays in it almost to the head of Barrett Run where the crest of the anticline is crossed. The axis of the anticline appears to cross Little Mahoning Creek about a half mile west of the sharp bend to the west, to cross the head of Barrett Run and Kinter Hill, and leaves the quadrangle a mile north of the southwest corner. On the east side of the axis the structure is not so clear, owing to uncertainties in the correlation of the coals in the valley of Little Mahoning Creek. Apparently the beds descend over 100 feet from the divide southwestward to Nashville, and become still lower at Deckers Point, where the E coal is down to 1600 feet. The E coal descends to 1500 feet at a point one mile southeast of Deckers Point where the Dixonville syncline enters the quadrangle. This syncline appears to follow down the valley of Little Mahoning Creek from the point mentioned as far as Robertsville, where it is pinched out by the coalescing of the Chestnut Ridge anticline and the Kinter Hill anticline.

Coal.

All the workable coal beds in this district are in the Allegheny group. The E, D, C′, and B beds are of commercial thickness. The A′ coal is believed to be present, and the C′ coal has over it locally a lens of cannel coal, a feature characteristic of that coal elsewhere in the State.

E coal. At the few openings where the E coal could be examined it appeared to be everywhere a solid bed without partings, overlain in places by shale and in others by sandstone, and in still others by a sandy shale separated from the coal by one or two inches of bone. Usually clay with a limestone below it underlies the coal, though locally a little black shale is found between the coal and the clay.

Measured sections of the coal range from 3 feet 10 inches to 5 feet 2 inches, averaging a little over 4 feet. (See sections 30-31, Fig. 7).

D coal. The D coal in the few openings seen, measured from 2 feet 3 inches to 3 feet 8 inches, indicating a variable thickness. Under part or much of the area it may prove too thin to work under present conditions. The sections indicate that the coal is without partings, in places overlain with a few inches of bony coal and elsewhere underlain by bony coal. Over the coal is usually shale, and under it clay. (Sections 100-101, Fig. 9).

C′ coal. At three openings on the C′ coal the bituminous part of the bed measured from 30 inches to 5 feet 3 inches, indicating that much of the district may be underlain by workable coal at this horizon. At one place from 5 to 6 inches of bone overlies the bituminous bed. In the southwest part of the district the bituminous bed is overlain by cannel coal, having a thickness of 9 feet or less. The thickness, however, as is usual with cannel coal, is quite variable, the lens apparently having only a small extent, and decreases rapidly from 9 feet to one foot or less in the small mine.

No measurements were made on the C coal.

B coal. The B coal is exposed at several places along Little Mahoning Creek near Richmond and near Deckers Point. The coal ranges in thickness from 18 inches to 3 feet, and probably will show a local thickness somewhat greater than that. On the other hand it will probably be found too thin to mine in parts of the area. In most of the exposures the coal has no partings and is not associated with bony coal, being overlain with a shale roof and underlain with clay. Locally the coal contains a parting up to 1½ inches thick. (Sections 130-133, Fig 12).

A and A′ coal. Practically no measurements were obtained on the A coal and only a few on the A′. These ranged from 7 inches to 1 foot. This coal is 20 inches thick near Enterprise, so it is possible that it will prove to be workable over small areas in this district.

Distribution of resources.

In the northwest corner of the district Little Mahoning Creek flows over rocks near the base of the Allegheny group. On the hill southwest of Savan the E coal is about 200 feet above the railroad and the top of the same hill is capped by the Buffalo sandstone 200 feet higher. The E coal, 3 feet 10 inches to 4 feet thick, is mined on the George Richardson place. The top 10 or 12 inches of the coal is short grained and the rest long grained. The roof is brown shale, the floor light drab clay, reported to be 9 feet thick. Under the clay is limestone. At the mouth of Crooked Run, opposite Richmond, the Vanport

limestone outcrops and has been dug for agricultural lime. Part of the limestone was taken by stripping and part by mining into the hill. The limestone is reported to be 5 feet thick. Over it is exposed some 15 feet of blocky to splintery light drab shale, and under it is coal 6 to 12 inches thick, underlain by 15 feet of sandy, dark drab shale. The limestone is at road level at Savan (Ae 3) but following the road to the east rises in the hills to be 15 or 20 feet above the road. The top of the Clarion sandstone appears in the bed of Crooked Run, and underlies the slope on the east side of that run. The sandstone rises to the east, reaching an elevation of about 1530 feet where it outcrops on Beech Run and of 1600 feet on Barrett Run, approaching the crest of the Kinter Hill anticline. In that region it makes distinct bluffs at the top of the steep hillside, and along the spurs projected toward Little Mahoning Creek. The Pottsville series must outcrop below it in the hillslope though it was not seen except in small sections of a few feet each in Beech and Barrett runs. The A′ coal immediately overlies the Clarion sandstone at several points on the road from Richmond to Ord post office. Where the road crosses the divide the E coal is just above it. The D outcrops on both sides of the gap (Be 7 and 8). Just beyond the gap (Be 10) the D coal has been opened and worked a little. The coal measures 32 inches thick, including 1 inch of shale 4 inches from the bottom, but not including 5 inches of bone separated from the bottom of the coal by 6 inches of clay. The roof here is shale. Thirty-five feet above the opening on the D coal is an old opening on the E, now fallen shut (Be 9). Other outcrops of the D coal were seen in this neighborhood and to the northeast about Doty Roundtop. The same two coals have been opened near the head of Beech Creek (Ae 10-11-12). The E coal is reported to have a thickness of 4 feet and the D a thickness of 3 feet. The two beds are 54 feet apart. The top of the hill on the road past this point from Richmond to Hillsdale is for a distance in the Conemaugh shale, and a large amount of the olive flinty shale and clay is exposed both on the road and in the fields near the road. A number of coal blooms were seen in the northeast corner of the district over the slopes of Doty Roundtop, but no exposures at which the coal could be measured. The massive Clarion sandstone is about 120 feet above creek level at the point where Little Mahoning Creek turns from north to west, on the east side of the anticline. It continues to have about that position along the creek south to Ord. Near the mouth of Rairigh Run it appears to go under drainage, and at several points are outcrops of the B coal. About 1¼ miles southwest of Ord (Bf 1-2-3) the B coal is 32 to 36 inches thick. On the Cornelius Roley place (Bf 2) the coal, 3 feet thick, is overlain by shale and underlain by 7 feet of clay. The correlation of this coal as the B is based mainly on the thickness

of the clay, as none of the other coals in that part of the Allegheny group commonly have as thick a clay as that. At the John Romeley opening (Bf 3) the coal is 32 inches thick, overlain by shale and underlain again by 7 feet of clay, with one inch of shale between the clay and the coal. At (Bf 1) apparently the same coal bed is only 18 inches thick. Up Little Mahoning Creek from this point are numerous outcrops of coal, some of which are evidently in the position of the B but at none of them had the coal been opened so as to expose its thickness or quality. One mile northwest of Deckers Point the E coal has been opened on the Jim Beatty place (Af 5). The coal here is from 4 feet 9 inches to 5 feet 2 inches in thickness, overlain by 1 to 2 inches of bone and that by sandy shale, and underlain by 1 to 2 inches of black shale and that again by clay. The coal is here very near the top of the ridge and underlies only a small area. At the head of Crooked Run, the C′ coal has been opened on the Joe Brown place (Af 1) where it is 3 feet 8 inches thick and overlain by 5 inches of bone and that in turn by dark or black shale. The floor of the coal is shale. The opening is directly under the road near the top of the hill. Off from the road a short distance is the S. L. Lowry and S. J. Bash opening on the C′ coal, which at this point carries several feet of cannel coal. In one part of the mine the cannel coal was only one foot thick and underlain by 3 feet 4 inches of bituminous coal. In other parts of the mine the cannel coal measures as high as 9 feet. Over it is 6 inches of bone and above that black shale. The floor is clay. As usual with cannel coal, it has a distinct blocky character, the joints or "slips" being marked, and the "face" having a S. 85° E. direction. Other openings have been made on the coals farther down Crooked Creek but all of these had fallen shut when visited. On the south side of Kinter Hill an outcrop of the E coal was noted (Af 4), underlain by limestone and overlain in a few feet by the yellow flint clay of the Lower Mahoning. The Upper Freeport limestone outcrops at the forks of the road west of Kinter Hill (Ae 15) and again at a saddle in the top of the hill to the north (Ae 7). At the latter point, on Mr. Work's place, the limestone is 3 or 4 feet thick and has been burned for agricultural lime. Below this saddle, three-quarters of a mile south of Richmond (Ae 5), what was thought to be the C′ coal has been worked on the Jeffries place. The coal is 30 inches thick, overlain by dark drab fissile shale, and underlain by 1 inch of bone, and that by drab clay. On a small tributary of Crooked Run (Ae 6) is the Aaron Jeffries mine on what is thought to be the C′ coal. The coal here is from 5 feet to 5 feet 3 inches thick. It is overlain by 5 to 6 inches of bone and that by clay shale. The floor of the mine is bony coal.

As shown by these local details, practically the whole district is underlain by the B coal, and the E coal is confined to a rather limited

area near the top of the hills. The D and C′ coals underlie somewhat larger areas and at slightly lower elevations. The structure contours on the map show the elevation of the E coal at any point in the district, and the position of the other beds can be determined by subtracting their distance below the E from the elevation of that bed.

NEWTONBURG DISTRICT

Introductory statement.

The Newtonburg district includes the land in the northeast corner of the quadrangle lying east of Mahoning Creek and Clover Run to the head of Stony Run and north of Pennsylvania and Northwestern division of the Pennsylvania Railroad from North Summit to the eastern edge of the map. The axis of the Chestnut Ridge anticline runs through this district, raising the formations much higher than they are farther south, and the existence of a massive hard sandstone in the upper part of the Mahoning formation tended to preserve the crests of some of the ridges at an elevation of 2,200 feet above sea level, or more. From these crests the streams have cut deep gorges down to the level of Mahoning Creek on the northwest and to the West Fork of the Susquehanna on the southeast. The topography and the fact that the hill slopes are covered with massive sandstone blocks and debris from the Upper Mahoning sandstone that caps the ridges, render most of the district incapable of cultivation and of little value, except for timber and minerals. The Buffalo, Rochester & Pittsburgh Railway along the northwest edge of the district and the Pennsylvania and Northwestern along the south edge of the district give ready transportation facilities. The New York Central Railroad crosses the southeast corner of the district. Newtonburg, a small lumber camp, was the only town in the district when studied.

Stratigraphy.

The rocks of this district consist of 110 to 120 feet of the lower part of the Conemaugh group, the underlying Allegheny group, and the upper part of the Pottsville series. The Conemaugh, as exposed in this district, consists first, of a massive sandstone in the upper part of the Mahoning formation between the Mahoning coal and the Brush Creek coal. Only a few feet of the shales overlying this sandstone occur in the district and as a rule the massive sandstone forms the tops of the hills. Possibly small areas of the Brush Creek coal will be found, but as that coal is very thin these can have no economic value. Under the Mahoning sandstone is 50 to 80 feet of shale.

The rocks of the Allegheny group are at the surface in most of the district. The whole group lies between Newtonburg, Hillman, and Bear Run. The E coal at the top of the Allegheny group appears to be workable over much of the district, though it is thin or lacking in a few of the places where the rocks were measured. The D coal is commonly present and is workable at many points, though usually not exceeding three feet in thickness and most of the sections show less than that. In some of the exposures it is thin or absent. Between the E and D coals are the underclay of the E coal, then the Upper Freeport limestone, which in drill holes appears to range from 10 to 20 feet thick, then shale to the D coal. Below the D coal in several sections is a sandstone corresponding to the Freeport sandstone. The C′ coal is usually thin or absent, though one drill hole pierced 2½ feet of coal. Below that again is generally shale with a little sandstone to the C coal, which is absent in most of the sections. The B coal is present at a few points something over 200 feet below the E coal. It is thin where seen, although of workable thickness locally. Sixty feet below the B is the A coal which is of workable thickness and probably the thickest coal of this district, reaching four feet in places, though rather badly broken up with partings. Between the B and A coals is a massive sandstone in the position of the Clarion. It is this sandstone that is so prominent around McGees Mills. It is 30 to 40 feet thick there, and coarse grained to conglomeratic. Under the A coal is a sandy clay.

The upper part of the Pottsville series is exposed in this district in the southeast corner, along Bear Run. The Homewood sandstone is crossbedded, fairly massive, of low grade, and not thick. Two coal beds beneath it are exposed at several places a short distance northwest of McGees. A section showing the relation of these two coals is given on Plate IV.

The Homewood sandstone presumably is present in Laurel, Lost, and Clover runs and has been so mapped because the valleys are cut deep enough below the Upper Kittanning coal to expose the sandstone. A thick layer of hill wash, however, masks any exposures of the rock.

Structure.

The general structure in this district is well determined but not the details. The massive sandstone in the upper part of the Mahoning formation caps the ridge tops and covers them with debris. Large sandstone blocks also mantle the hillslopes so that there are few natural outcrops. The E and D coals are seen at enough points along the high divide to make a good check on the geologic structure as determined from the massive sandstone capping the divide. The general character and amount of the rise of the rocks on the Chestnut

Ridge anticline are shown by the position of the E coal on the East Branch. At Big Run the E coal is 1250 feet above sea level, and north and west of Newtonburg it has an elevation of 2100 feet, a rise of 850 feet in 4½ miles. The rocks appear to lie flat across the top of the anticline, and then descend sharply to the West Fork of the Susquehanna at McGees Mills, where the E coal has an elevation of 1600 feet, a descent of 500 feet in 2½ miles.

Coal beds.

All the workable coal in the Newtonburg district appears to be in the Allegheny group, though it is possible that one or both of the Mercer coals of the Pottsville may prove to be workable locally. The A or Brookville coal has been opened at more points and is thicker than any other coal in the district.

E coal. The E coal underlies the crests of the hills, and usually is thick enough to mine, as shown in Fig. 7, sections 17-19.

The coal ranges from 2 to 4½ feet in thickness, and has one or two partings, sometimes of clay, more often bony in character. The roof is shale and the floor fireclay.

D coal. The D coal appears to be a solid bed ranging from 2 to 2½ feet in thickness. The roof as far as seen, is shale and the floor clay. Both the E and D coal beds appear to be lacking in some places.

C coal. The C coal is reported in the records of some drill holes as of workable thickness but an exposure seen near Mahaffey indicates that only a small portion of this may be of saleable quality. At that point the bed consists of 8 to 13 inches of good coal, and of 2 feet or more of black shale or bone. In other places the coal is one to two feet thick and unaccompanied by black shale or bone.

B coal. The B coal between Mahaffey and McGees is 18 to 22 inches thick. Locally it will probably prove workable. It is overlain by sandstone in the region mentioned and underlain by a fine body of clay.

A coal. The A coal in the Newtonburg district is shown in sections 145, 147-150, and 156, Fig. 13. It varies in thickness from a mere film or a few inches to 5 feet. In some places it is a solid bed without partings. More commonly it has at least one or two partings of bone or shale. They occur in various positions. The roof is sandstone, usually with a little shale intervening between the coal and the sandstone. The floor is clay.

Distribution of resources.

The Conemaugh rocks occupy only a limited area in this district. They cap the ridge from above Newtonburg west to the head of Stony

Run, the broad ridge north of the head of Whisky Run, and parts of the tops of the long spurs on both sides of Laurel Run. Only 110 to 140 feet of the Conemaugh group remains in this district, except north of East Run. From the distribution of the Conemaugh it is readily seen that the E and D coals are both confined to the tops of the ridges. The E coal occurs immediately below the base of the Conemaugh group and the D coal some 40 feet lower, occupying only a slightly larger area, because, as a rule, the hillslopes below the outcrop of the Conemaugh are quite steep. As the Conemaugh contains a massive sandstone in the upper part of the Mahoning formation, the area underlain by that sandstone on the crest of the anticline is flat topped. The main slopes through the districts are in rocks of Allegheny age. Unfortunately there are few exposures of those rocks, owing to the mantle of massive sandstone blocks which come down from the outcrop of the Mahoning sandstone. The base of the Allegheny group is about at water level near the head of Bear Run, on Whiskey Run a little below Newtonburg, and probably is not far above water level on the head of Laurel Run. The dip carries the rocks down rapidly so that at the mouth of Laurel Run about one-half of the Allegheny group is below drainage. The base of the Allegheny group should be near or just above water level on Clover Run for three or four miles, but bed rock is hidden by hillwash.

The small area between Mahoning Creek and East Branch is underlain by rocks mainly of Conemaugh age. The top of the Allegheny group is exposed along the west and north bank of East Branch to a thickness of 50 or 60 feet. The McClure Mining Company has opened the E coal at the mouth of East Branch (Da 6) at an elevation of 1300 feet. The bed is 3 feet thick and without partings or bone. From the mouth of Clover Run the top of the Allegheny descends rapidly to the level of East Branch at its mouth. Outcrops of what is considered to be the Bakerstown coal, associated with red shale, were seen in the ridge spurs three-quarters of a mile north of the mouth of Laurel Run (Ea 1 and 2). The D coal has been mined a mile farther east in the south part of Brady township (Fa 4). At the latter place the coal is 30 inches thick, overlain by dark fossiliferous shale and underlain by dark clay 4 feet thick, and that by dark shale. The E coal outcrops in the saddle of the hill 30 feet higher (Fa 5), 1660 feet above sea level.

In the area between Laurel Run and the northeast corner of the quadrangle the E coal occupies the crests of all of the hills under thin cover. The D outcrops at a number of points and has been mined at the north edge of the quadrangle as just described. The E coal has been mined on the head of Laurel Run at Fa 1 at an elevation of 1980 feet above sea level, at Fa 2 on the Fred Frantzer Place, and at Fa 3.

At Fa 1 the coal is badly broken with bone partings, the thickest bench of coal being only 2 feet. Above that are: bone 2 inches, coal 6 inches, bone 4 inches, coal 1 inch, bone 6 inches, to shaly sandstone. Below the coal is clay. At the Frantzer bank the coal is 3 feet thick with a one inch parting in the middle. It is overlain by 4 inches of black shale and that by a lighter shale, and underlain by clay.

If the coal at the Frantzer bank is the E, the base of the Allegheny should be just above water on Laurel Run, where the run changes its course from southwest to north. Descending the run the dip keeps the base of the formation about even with the grade of the stream, but in the last two miles the grade of the stream becomes less and the dip of the coal becomes steeper so that the Allegheny group descends below water level in a short distance. On the Schlimmer place (Ea 4) coal has been worked that is thought to be the B.

Between Laurel Run on the east and north, and Clover Run and and Lost Run on the west and south,t he E coal occupies limited areas in the crest of the divides. It has been mined in a small way on the Hoover place (Eb 1) and outcrops on the road to the south on both sides of the saddle. Nearly or quite all of the Allegheny coals outcrop between the mouth of Lost Run and the top of the ridges nearby, as the top of the Pottsville must be very close to water level on Clover Run. Between Lost Run and the head of Clover Run are numerous outcrops of the E and D coals and near the head of Clover Run both coals have been mined commercially at the Clover Run mines of the Madeira Hill Coal Mining Company (Fb 6-22). The No. 1 mine is in the E coal. The coal is 2 feet 4 inches thick with black shale roof. It has an elevation of 2130 feet above sea level, or about as high as that coal gets in this quadrangle. At the No. 2 mine the D coal is being worked, the coal having the same thickness but a little poorer quality. The two coals outcrop on both sides of the low divide between the heads of Clover Run and Whiskey Run (Fb 1- 2-4-5). The broad flat at the head of Whisky Run is underlain by the Upper Mahoning sandstone. The E coal is about 100 feet below the top of the ridge and the Allegheny coals are in succession under it. The E coal outcrops on the eastern edge of the quadrangle south of this broad flat at Fb 8 and the D coal outcrops farther south along the same road a little to the east of the quadrangle and again inside the quadrangle at Fb 9.

The ridge west of Newtonburg is capped by the Upper Mahoning sandstone with the E coal outcropping at many points about 100 feet below the top of the ridge. Among those points may be noted Dc 9, Ec 1 and 2, Fb 2 and 3. The hills on the south edge of the district are cut below the position of the E coal. Coal beds exposed in that region are mainly those at or near the base of the Allegheny.

Around McGees Mills the A coal is exposed at a number of points and has been mined at the old McGee mine, now the Standard No. 1 of the Beccaria Coal Company (Fc 4). At this mine the bed shows at the top a 6 to 7 inch bed of coal, then from 4 to 5 inches of bone and shale, then 33 to 34 inches of coal and 1 to 3 inches of shale, then 6 inches to 4 feet of coal at the bottom, averaging about 13 inches. This coal is well exposed in the railroad cut just east of the station at McGees where it is 4 feet thick. Over it is from 6 inches to 4 feet of shale with many iron concretions.

The base of the sandstone (Clarion) which overlies the coal contains many stringers of coal from one-eighth inch to 8 inches thick and sometimes several feet long. These stringers are composed of bright coal with a small cubical fracture and several of them show 2 or 3 shale partings. It is assumed that they represent fragments of the A coal detached from the freshly laid bed by the water currents that carried the sand to make the Clarion sandstone. The A coal is only 16 inches thick where exposed beside the track (Fc 8). Under the coal in the cut are from 4 to 8 feet of poor sandy clay, then 12 to 15 feet or more of light brown to light drab sandstone (Homewood).

Both the Clarion and Homewood sandstones extend up Whisky Run. At the first east-west road crossing Whisky Run, north of McGees, the top of the Clarion sandstone on the west side is 1660 feet above sea level, but the dip brings it down to 1610 feet on the east side. Below the top of the outcrop the ground is strewn with great boulders of sandstone so as to preclude cultivation. In the road at the forks of Whisky Run one mile above its mouth (Fc 10) is an outcrop of coal 20 inches thick, apparently in the position of one of the Mercer beds.

On Bear Run along the Pennsylvania Railroad the rapid rise of the rocks to the northwest is readily noted. A short distance from the New York Central crossing is a partial exposure of one of the Mercer coals below which may be seen a few feet of the Connoquenessing sandstone, at this point a thin, even bedded, sandstone and shale. Seventy feet above this are old openings on the A coal and the Standard No. 1 mine of Beccaria Coal Company. A short distance up the road northwest from McGees, the Clarion sandstone has been quarried rather extensively (Fc 1). The sandstone here is a medium coarse, even-grained gray to almost white sandstone, showing a solid face 20 feet thick or more. As the sandstone rises almost as fast as the surface, the stripping is very slight. Farther up the hill and just above the sandstone is an outcrop of the Clarion flint clay (Fc 11). At the fork of the road (Fc 15), ¼ mile beyond, is the Shadyside mine of the South Branch Coal Company. The coal is 38 inches thick with a 1-inch binder 10 inches from the bottom. It is identified as the B

coal. The C or C′ coal outcrops at the high point in the road 1½ miles northwest of McGees (Fc 12). The top of the Clarion sandstone outcrops in the head of the run that lies south and west of this road. At the mouth of this run both of the Mercer coals are exposed only a few feet above the level of Bear Run. The upper bed is 22 inches and the lower is about 2 feet thick (Fs 2 and 3). The section at this point has been given in the general description of the Pottsville series (page 30). For a distance, the railroad grade rises faster than the dip so that 1½ miles west of McGees (Ec 7) the A coal is again at railroad level. The coal is here 38 to 48 inches thick with a 2-inch parting of coal and bone from 5 to 12 inches from the top. Over the coal is 8 inches of blocky, black shale with drab and rusty brown shale above. Clay underlies the coal. On the east side of the run at Sidney the following section was seen.

Section east of Sidney.

	Ft.	in.
Sandstone irregularly bedded	10	
Sandstone regularly thin bedded	15	
Sandstone irregularly bedded	1 to 4	
Clay	0 to	6
Coal	1	2
Clay, sandy, almost sandstone	3	
Clay, shaly	2	
Shale, drab	1+	

From its relation to the openings on the A coal last mentioned and at the Bear Run No. 1 mine, the coal in this section would seem to be the A bed; but careful tracing of the bench at the top of the Clarion sandstone indicates that it is probably the Upper Mercer coal, and the overlying sandstone is the Homewood. Just at the east end of the trestle some 8 feet of the Connoquenessing sandstone shows, which at this point is a white, massive, coarse-grained sandstone. Under the railroad are two cliffs of sandstone about 10 feet high separated by a sandy shale. Just west of the station at Sidney is an outcrop of flint clay.

Just north of Sidney station, and 50 feet above the railroad track, is the Banks No. 1 mine. The coal being worked here is apparently the A, though the massive Clarion sandstone does not show prominently above the coal at this point. Many large boulders of white sandstone cover the ground about on the level with the coal, but do not appear above the coal, though the existence of a distinct bench at the top of the boulder-strewn ground to the east of this point suggests strong-

ly that the Clarion sandstone belongs to this coal. At the mine the coal shows a thickness of 3 feet 2 inches, underlain with 8 inches of bone and that in turn by 8 inches of coal on a clay floor, the clay being 4 feet thick. The roof is shale. North from Sidney the coal keeps well above drainage with apparently a massive white sandstone a short distance below it. A little over one mile north of Sidney an opening apparently at this horizon shows only 14 inches of coal. Another coal, probably the B, has been prospected 102 feet above this opening, and is reported to be 3 feet thick with black shale roof (Ec 8). Apparently the same coal as at the upper opening has been dug into in the northeast corner of Indiana County (Ec 9), where it shows a thickness of 8 to 13 inches, overlain by brown shale. At Ec 10-12 are outcrops of what is thought to be C′ coal. At Flinns, the Kanma Coal Mining Company has a mine, the Emlou No. 1, on the A coal (Ec 14) at an elevation of 1694 feet. The average section of the bed is reported to be: Roof coal, 5 inches, bone 3 inches, coal 3 feet 6 inches.

The axis of the Chestnut Ridge anticline appears to cross Bear Creek a little above Flinns. Beyond this point the beds dip to the northwest, descending rapidly so that at North Summit nearly all of the Allegheny is below the railroad track.

GLEN CAMPBELL DISTRICT

Introductory statement.

The Glen Campbell district lies a little southeast of the center of the quadrangle. It is bounded on the north and east by the Pennsylvania and Northwestern Division of the Pennsylvania Railroad from North Summit to McGees Mills, and by the Pennsylvania Railroad from McGees Mills almost to Hooverhurst; thence the boundary runs northwest and down Salsgiver Run to Straight Run, up Straight Run to the head, and past Flora by the road to North Summit. The northwest part of the area is high and sub-level on the ridge tops, with fairly steep slopes to the branches of Bear Run. The central and southeastern parts of the district have only a little sub-level land on top of the ridges and the slopes are somewhat steeper. The area ranges in elevation from about 2,000 feet on a number of the high points to below 1300 feet at McGees Mills. Some flat bottom land exists along Cush Creek and the West Branch of Susquehanna River. Glen Campbell is the principal town. Johnsonburg, Smithton or Hortons post office, and Urey are hamlets in the district. The Pennsylvania Railroad bordering this district on three sides and the New York Central Railroad following its eastern and part of the southern edge, provide abundant facilities for the removal of the coal or other economic products.

Stratigraphy.

In this district the rocks are almost entirely of Allegheny age; hardly more than 100 feet of Conemaugh rocks occur in any part of the district and those over a very small area only. The Pottsville outcrops to a slight extent in the valley of Bear Run and the West Branch of Susquehanna River near McGees. The Conemaugh group consists only of the Mahoning formation, including the Upper Mahoning sandstone which has been quarried to some extent in the hills two miles north of Glen Campbell. The lower part of the Mahoning formation consists almost entirely of shales, in places becoming flinty in character.

Allegheny group. The various coals of the Allegheny group are better exposed in the south half of the Glen Campbell district than anywhere else in the quadrangle. The E, D, B, and A coals are all being worked commercially and in addition the C′ coal shows a workable thickness. Between the E and D coals are about 30 to 40 feet of rocks which, as far as seen, are almost entirely shales. The E coal is from 3 to 4 feet or a little more in thickness. The D coal is quite variable; locally it is 9 feet or more thick, though in general from 4 to 5 feet or less. The C′ coal ranges from one foot to over 3 feet in thickness and underlies the D coal by about 40 feet, the interval in some places being almost entirely sandstone and in others almost entirely shale, though usually with some sandstone in the lower part of the interval. Between the C′ and B coals are usually found one or two coals which may locally have a thickness of up to 2½ feet, though usually they are less than 2 feet thick. The rocks of the interval consist largely of shale though a few sections show heavy beds of sandstone. The B coal ranges from 2 feet to over 4 feet in thickness, and outcrops only in the valleys. Below the B coal are two coals, one of which may be assumed to be the A or A′ and the other either the A or the Mercer coal, according as the upper or lower of the two be correlated as the A. Between the B and the A coals is usually shale with some sandstone or sandy shale. One drill hole record shows a little limestone about in the position of the Vanport limestone but no limestone was seen in outcrop at that part of the section.

Structure.

The Chestnut Ridge anticline crosses the west part of this district, and holds the E coal more than 1900 feet above sea level on most of the head waters of the south branch of Bear Run. From this elevation the rocks descend rapidly to Cush Creek and the West Branch of the Susquehanna, where the same coal is only 1400 feet above sea level. Around Glen Campbell the dip is very sharp 450 feet in 2 miles.

Locally it is even steeper than that. The anticline broadens out in the Johnsonburg region, and to the southwest divides, one branch passing south just west of Smithport and the other to the west of Robertsville. The rocks of the Conemaugh group are gone from most of the northwest part of the area, as well as the E and D coals. But those coals and the capping Conemaugh rocks are found in the hills about Glen Campbell.

Coal.

The several coals of the Allegheny are fairly well exposed around Glen Campbell. Of these the E and D have been mined the most, though openings have been made on both the B and A coals.

E coal. The E coal appears to be workable over this district wherever it has sufficient roof. It contains from 2 to 5 feet of solid coal, often accompanied by one or more benches of good coal. The sections 33-41, Figs. 7-8, give a number of measurements on this bed, showing its thickness, partings, bony benches, roof, and floor. As will be noted, the bony benches appear at either the top or bottom of the coal, or in one case in the coal. They range in thickness from 1 to 6 inches. The roof of the coal in all places noted is a drab to black shale. Above the coal is usually 50 feet or more of drab or olive shale, though in some areas a sandy shale, and in a few places a hard sandstone occupies this position. The floor of the coal is clay of yellow and drab color.

In places the coal is noted as differing considerably in grain in different parts of the bed. Thus at one opening near Smithport, where the coal is 52 inches thick, the upper 12 inches is cubical in structure. Then 22 inches of "stick coal," or long-grained coal, then, below a smut mark, 20 inches of partly cubic and partly stick coal. Another opening in the same neighborhood showed 4 inches of bone forming the roof, 16 inches of cubic coal, then 34 inches of stick coal. Below the E coal is often found a limestone and in many places some fire clay.

D coal. The D coal (see figure 9, sections 87-98) is much more variable than the E coal in this area, in places it is almost 16 feet thick, and in others thins down to 2 feet or less. Where it is thickest it is divided into several benches by rather heavy partings, as at the Cessna bank, where the greatest thickness was measured. Here the main bench is 6 feet thick, separated by 5 inches of clay from a lower bench, 2 to 2½ feet thick. Over the main bench is a parting of nearly 3 feet of light drab clay and shale containing a 7-inch band of coal near the middle. Above that is a 4-foot bench of good coal. As the parting under the 7-inch bed of coal is clay, from 8 to 12 inches of the top of the main bench is left for a roof in mining. As shown in the sections, in a few places the coal occurs as a solid bed 4 to 5 feet

thick. More often it is from 3 to 3½ feet thick, accompanied by bony benches either above or below, or separating benches of good coal. These bony benches are from one or two inches to 18 inches thick. In general the roof of the coal in this district is shale, though sandstone forms the roof in a few places. The floor is clay. In mining, one of the benches of bone is usually left as a roof or floor.

C′ coal. Though not being mined, drilling indicates that the C′, or Upper Kittanning, bed in this district is workable in some places. As reported by the driller, it is without partings, and from 1½ to over 3 feet thick, the roof being either shale or sandstone, and the floor clay or sandstone.

B coal. The B or Lower Kittanning coal is being worked on Horton Run, where it shows a total thickness of over 5 feet. Part of this is in underlying benches. At one point a 3-inch and 8-inch bench of coal separated by 6 inches of clay are overlain by 2½ inches of clay, and this by the main coal bench 32 inches thick. At another point not far away the principal bench measures 44 inches. In general the coal seems to carry one bench approximating 3 feet thick. Only one of the sections shows bony coal, though many of the sections show the bed split into one or more benches by clay partings from one-half inch to 6 inches thick. The roof is shale and the floor is clay in all sections noted.

A coal. The A coal outcrops along the South Branch of Bear Run from its mouth to a point north of Glen Campbell. In one opening 4 feet 2 inches of coal were measured, overlain by drab, fissile shale. Other sections of this coal in this district showed about 4 feet of coal, though these sections had one or two partings of bone or shale. In general it would appear that this coal may prove of workable thickness and quality under much of the district. As the A coal is apt to be high in ash it should be tested chemically before any large amount of development is undertaken on it.

Distribution of resources.

The northern part of the district in the area between the North and South Branches of Bear Run, and Straight Run on the west, is on the crest of the Chestnut Ridge anticline, so that the rocks are high above sea level as compared with their position in most of the quadrangle. Over most of this area the Upper Freeport coal has been removed by erosion. Small patches of it remain, however, in the hill east of Flora, in the hill one mile south of Johnsonburg, in the hills north of Smithport, and in the tops of the ridges between the North and South Branches of Bear Run. Most of the hilltops around Johnsonburg are underlain by the Kittanning and lower coals. The tops of the

ridges appear to be held up by a sandstone between the D and C′ coals. Coals from A to C′ should outcrop in the slopes on both branches of Bear Run. The A coal is above drainage up the South Branch as far as the road from Glen Campbell to North Summit.

The A coal has been opened at 2½ miles north of Smithport (Dd 2) on a level with the creek bottom where 4 feet 2 inches was measured, overlain by drab fissile shale. The bottom of the coal was not reached. It was reported as 4 feet 4 inches thick. The well at the mill just below the road is said to have struck a coal bed at 42 feet below the A coal containing: coal 16 inches, sandstone 18 inches, and coal 18 inches. One-half mile down the branch (Dd 26) is the Banks No. 3 mine on the A coal which is 38 inches thick with 5 inches of bone on top. In the hollow one-half mile north of this locality in the Banks No. 4 mine the A coal 38 inches thick is overlain by 3 inches of bone and a 4-inch roof coal. Farther down the branch, three-quarters of a mile southwest of Sidney (Ed 1), the A coal is 60 to 70 feet above the creek. Here in the Banks No. 2 mine the section of the A coal differs from that in Banks No. 3 mine in that the main bench is 41 inches thick. Prospecting on the point south of Sidney between the two branches of Bear Run at the horizon of the A coal shows 30 to 40 feet of drab sandy shale but no coal. Coal was struck just across the South Branch at Ed 2.

The B coal outcrops on both sides of the South Branch of Bear Run 2½ miles north of Smithport (Dd 1 and 3) and 90 feet vertically above the A coal. The dip is to the southeast so that the elevation of the outcrop above the creek on the north bank is more than 90 feet, and on the south bank less. Just under the coal at both outcrops is the debris of flint clay indicating a deposit of more than usual thickness. Thirty feet above the outcrop of the B coal on the north side of the creek is an outcrop of the C coal (Dd 25). In addition to the outcrops mentioned, the E coal occurs around Flora (Dc 10), and in the tops of the ridge north of Smithport (Dd 20-21-22).

The ridge in the northeast part of the district between Bear Run and Susquehanna River consists mainly of Allegheny rocks. In the New York Central Railroad cut, west of the trestle over the Pennsylvania Railroad at McGees, the Clarion sandstone makes 20-foot bluffs, being a massive cross-bedded, coarse, almost gritty, even-grained sandstone. As the railroad turns to the southeast the dip brings the top of the sandstone down to track level, exposing the B coal, underlain as usual with a good bed of clay, in this place 8 feet thick. At the point of the hill in the deep cut just north of where the track crosses the river is an exposure of a coal bed 19 inches thick (Fd 2), thought to be the B coal, and underlain by 4 feet of drab clay. At this point the shales overlying the coal have been greatly disturbed as indicated

by the sketch (Fig. 3). The appearance is that of horizontal faulting with an overriding by the overlying sandstone.

The same coal shows again lower down the same point of land on the Pennsylvania Railroad where it is 22 inches thick, underlain by 6 feet of fine light drab clay. Where the Pennsylvania Railroad crosses the horizon of the A coal, between this point and McGees Station, the coal appears to be lacking, its place under the massive sandstone being taken by a little black shale, overlying 3 feet of dark clay.

Southward from McGees the Susquehanna River valley lies nearer the bottom of the syncline, so that instead of being in Pottsville rocks, the river is cutting in rocks of middle Allegheny age. The spurs from the divide, between the South Branch of Bear Run and Cush Creek, carry the E coal to within short distance of the river. The E coal occupies only a few limited hilltops to within a mile of Urey. North of Urey the E coal shows at (Ed 4) and the D coal makes prominent blooms in the road at (Ed 5-6 and 7). The lower parts of the ridge top are held up by the massive Freeport sandstone which comes between the Lower Freeport and Upper Kittanning coals. Locally, as in the general region round Johnsonburg, this sandstone is resistant and part of the ridge slopes are strewn with its debris.

What is apparently the C′ coal has been worked at the Reuben McMaster mine (Ed 11). The Urey mines extend from Urey southeastward down McCoy Run to Cush Creek. They are on the D coal while the E coal lies some 35 feet higher. At the outcrop (Ed 7) the D coal is in three benches consisting of: 26 inches of coal at the top, 6 inches of drab shale, 25 inches of coal, 14 inches of purple-drab clay and 7 inches of coal. In the Urey mines only the middle bench of coal is worked, consisting of from 3 to 3½ feet of coal with an inch of bone a little less than half way up from the bottom. Over the coal is 18 inches of bone which makes the roof. Mr. Peck gives the following measurements from Mines Nos. 1, 5 and 3. Mine No. 1 (Ed 8) shows in the roof sandy shale, 5 feet plus; bone coal, 1 foot to 18 inches; coal, 2 feet; bone, 5 inches; coal 1 foot plus. No. 5 (Ee 3) shows a roof of sandy shale to thin bedded sandstone; coal, 6 inches; bony, 6 inches; coal, 3½ feet plus. No. 3 Mine (Ee 5) has a roof that varies from shale to thin bedded sandstone, 4+ feet thick; then bony coal, 7 inches; coal, 7 inches; bone, 7 inches; coal, 2½ to 3 feet; bony (?) hard coal, 1 foot plus. The dip of the coals is well shown in following down the run from Urey or the east-west road north of Urey. The D coal outcrops at (Ed 5) at about 1765 feet. Coming south toward Urey an outcrop is seen at about 1750 feet. At the No. 1 mine the coal is at 1664 feet above tide; at the No. 2 mine, 1562; at the No. 5, 1490; at the No. 3, 1475; and in the point of the hill south of the No. 3 the coal is 60 feet still lower. Both coals outcrop at a number

of points east of the No. 3 mine and both have been opened at small mines (at Ee 6 and 7), where the two coals are less than 25 feet apart.

At the point of the spur west of Cush Creek Junction the Cushake mine (Ee 23) is in the E coal. The bed is 3 feet 8 inches thick, including 6 inches of bony coal at the top and a 2-inch binder between two 18-inch benches. The roof is shale and the floor fire clay. The D coal is 14 feet below, with the following section: Roof coal 14 inches, slate binder 8 inches, coal 20 inches, clay binder 10 inches, coal 20 inches. This is typical of the D coal in some areas, as shown by the sections in Fig. 9. These measurements were furnished by the Cushake Coal Mining Company who believe their mine to be in the D coal.

The Mahoning sandstone caps the highest point of the ridge northwest of Urey, (Dd 7) where it has been quarried a little. The E coal outcrops one mile northwest of Urey (Dd 5) and the D has been mined there (Dd 4). On the hillside three-quarters of a mile northwest of Urey (Ed 3) is the Cessna mine in the D coal. The writer measured the following section in this mine: shale; coal, 7 inches; light drab clay, 12 inches; coal, 8 to 12 inches (is left up for roof); coal (mined) 64 inches; shale, 5 inches; coal 27 inches; clay. Above the upper 7 inches of coal in this section, Mr. Peck found: clay, 16 inches; coal, 6 inches; clay, 12 inches; coal, 48 inches. See Fig. 9, sections 96 and 97. Both the E and D outcrop just west of the top of this hill in the roads (Dd 6 and 8). On the road to the north near the South Branch of Bear Run is an outcrop of the B coal, as already mentioned (Dd 3), underlying which is an exposure of flint clay. On the ridge to the southwest the E coal has been opened at the Depp mine (Dd 10) where the main bench is 3 feet 6 inches thick. Over that is 4 inches of bone, and under it is 1½ inches of shale, then 7 inches of coal. The same coal is being mined at the Glenwood No. 11 mine (Dd 11). Mr. Peck measured at this mine as follows: roof, 8 feet plus of shale; bone, 4 inches; coal, 1 foot; bone, 2 to 4 inches; coal, 3 feet; shale, 2 inches; bony coal, 10 inches; clay, 4 feet. At another point the writer measured as follows: drab to black shale, 2 feet plus; bone, 3 to 4 inches; coal, 39 inches; clay, ½ to 2 inches; coal, 6 to 12 inches. Some 22 feet below the mouth of the mine is the dump of an old opening on the D coal. The coal is reported at that point to have thinned down to 2½ feet, though it was 3 feet thick at the entrance of the mine. The E coal outcrops prominently in the road just west of the opening of the mine and at several points between that and the top of the hill northwest of Glen Campbell, as at Dd 14. At Dd 13 is the upper end of the No. 6 mine. Electric haulage from No. 11 mine has taken advantage of the No. 6 mine entries to haul through that mine down to the old No. 6 tipple at De 3. A measurement at

the upper opening of the No. 6 mine gave: black shale, 4 feet plus; coal, 49 to 60 inches; clay. This is on the D coal which has regained its thickness here. The E outcrops in the saddle just 30 feet above. East of the upper opening on the No. 6 mine is an opening on the E coal. At the lower end of No. 6 mine Mr. Peck measured: shaly sandstone, 4 feet plus; bony coal, 4 inches; coal, 14 inches; bone, 1 to 2 inches; coal, 2 feet; hard coal, 4 to 6 inches; clay. At De 4 the E coal has been opened and shows only 27 inches of coal overlain by drab shale and underlain by clay.

At the Glenwood Springs No. 4 mine (De 4) the D coal shows: shale, 4 feet plus; coal, 9 inches; bone, 2 inches; coal, 3 feet; bone, 4 inches; clay. At the No. 3 mine (Ee 1) the same bed shows: shale roof; bone, 4 inches; coal, 1 foot; bone, 2 to 4 inches; coal, 3 feet 6 inches; clay, 18 inches plus. The D coal has also been opened at the Sheppard mine on Brady Run (Ee 2), at the Glenwood No. 6 mine (De 3) and at the Patchin mine (De 6), and at other points on the west side of Graham Run (as at Ee 8). At the Patchin mine the coal is 5 feet thick, including 2 inches of shale 18 inches from the bottom. It is overlain by 3 inches of bone.

It is interesting to follow the dip down through this series of mines. The E coal at the Glenwood No. 11 mine is about 1880 feet above sea level, at the upper end of No. 6 about 1800, at the lower end about 1660, and at the opening near Cush Creek on the north side it is down to 1420. The coal is still lower on the south side of Cush Creek. Around Smithport the E coal outcrops prominently on all the roads and has been opened at a number of places. One-third mile north of Smithport (Dd 15) the coal shows under a dark drab shale: 4 inches of bone; 16 inches of cubical or short-grained coal; 34 inches of stick or long-grained coal; on a bone floor. Three-quarters of a mile west of Smithport (Cd 8) the same coal shows 17 inches of cubical coal under black and drab to pink shale; 22 inches of long-grained or stick coal; and at the bottom 20 inches of medium long-grained coal. At the east end of the village (Dd 17) the E is reported 5 feet thick; and one mile north (Dd 21) as 4 feet 10 inches thick. The D coal is reported as split near Smithport, the upper bench measuring 1 foot 6 inches and the lower bench 7 feet at one point and 5 feet at another.

Along Horton Run and in the ridge southwest of that run the E and B coals have been worked. In the Indiana No. 8 mine (De 16), on the E bed, the coal is overlain with 0 to 2 inches of bony coal, with a 5-foot roof of sandy shale. The coal is about 3½ feet thick. The D coal 42 feet under this is reported as 2 feet 4 inches thick. At the Indiana No. 2 mine (De 10) the B coal is being worked at 1456 feet above sea level. The coal is 3 feet thick, overlain by sandy

shale 3 feet plus, and underlain by hard bony coal 6 to 8 inches and that by clay. At the Indiana No. 3 mine (De 9), 1723 feet above sea level, again on the E coal, the coal is from 2½ to 4 feet thick, averaging 3½ feet, overlain by 4 to 6 inches of bony coal under sandy shale, and underlain by one inch of bone and that by 4 to 6 inches of coal, over clay. The D coal at this point is reported as 18 inches to 2 feet thick to the north and as 4 feet thick at the south. The second opening on the B coal at the Indiana No. 4 mine (De 10), shows: drab shale, 2 feet plus; coal, 32 inches; clay, 2½ inches; coal, 1 inch; clay, ½ to 12 inches; coal, 8 inches. Another measurement not far distant gave 44 inches of solid coal. Under the E coal in this ridge the D coal is found to range from 18 inches up to 4 feet in thickness. The E and D coals occur in the top of this ridge with a maximum cover of about 100 feet and descend to the southeast at about the same rate as the hill. The B has been opened at De 1 and 2. It is reported 4 feet thick at De 1 and 4 feet 6 inches at De 2.

GIPSY DISTRICT

Introductory statement.

The Gipsy district includes the land lying between Little Mahoning Creek and East Run on the west and Cush Creek on the east and between Salsgiver Run on the north and the south edge of the quadrangle. It includes the mining towns of Gipsy and Wilgus and the post offices of Hillsdale and East Run. The divide between the drainage to the Atlantic and to the Gulf of Mexico passes through this district in the form of a very irregular divide, extending around the heads of offsetting streams. The streams on the east flow by way of Cush Creek to the West Branch of the Susquehanna while those on the west flow directly to Little Mahoning Creek and East Run. There is little flat ground in the area, except small portions of the divide between Cush Creek and the branch flowing past Gipsy and Wilgus, and around Hillsdale. The rest of the district consists for the most part of steep slopes, in the main too steep to be cultivated. The higher parts of the ridges reach 1900 feet, while the valleys on either side are about 1400 feet in elevation. The New York Central Railroad enters the district, extending to the mines above Gipsy and Wilgus, and follows the east side of the district to Arcadia. Logging branches have been run from Gipsy over into the valley of Little Mahoning Creek.

Stratigraphy.

The outcropping rocks of the district consist of the Conemaugh and Allegheny groups. Toward the north the Conemaugh is confined

to the tops of the ridges. The ridges east and west of Wilgus contain 300 feet or more of Conemaugh rocks. No workable coal has been observed in the Conemaugh, nor is there any one stratum of sandstone or other rock that serves as a good marker or key horizon. Two fairly massive sandstones appear to form the crest west of Arcadia. The uppermost of these, caps the ridge directly west of Arcadia, and was estimated to lie 350 feet above the E coal. A still more massive sandstone caps the ridge north of that. It was estimated to lie about 280 feet above the E. The lower of these two sandstones is believed to correspond with the Hillsdale sandstone, as described in the Barnesboro-Patton Folio and may correspond with the Saltsburg sandstone of the folios covering the areas farther to the west.

The Allegheny group outcrops over practically all of the hill slopes in the north part of the district, except the crests of the ridges, and over most of the hill slopes in the western and northwest part of the district; but it is under Cush Creek south of Arcadia.

In this district the E coal is predominant, and has proved to be extremely regular in its section and thickness, wherever it outcrops. Apparently it is thinning out in the southeast corner under Hillsdale. The D coal appears to be thin over most of the district, though probably reaching workable thickness locally. The B coal is reported of workable thickness in some of the drill holes but in other sections no coal over 2 feet thick was found in its position, so it is not certain that a coal at that horizon will be uniformly workable under the district. The Allegheny group as shown in cuts, and by drill holes, is mainly shale, though several beds of sandstone appear, especially toward the base of the group.

Structure.

The axis of the Chestnut Ridge anticline runs through this district west of the center. The axis passes through East Run settlement and Smithport, and three-quarters of a mile west of Gipsy. Along the crest of the anticline, through most of the district the E coal has an elevation of between 1750 and 1800 feet above sea level, descending to 1350 feet at Hillsdale. Near East Run settlement the crest of the anticline becomes lower, and the E coal is less than 1650 feet in elevation at the south line of the quadrangle. On the west side of the anticline there is a slight descent to Little Mahoning Creek at Nashville.

Distribution of resources.

In the north and west part of this district the E coal occurs in rather narrow detached areas in the hilltops; but to the east and

south the dip carries it rapidly down to and under water level. North of Gipsy this bed underlies an irregular area, almost cut into detached areas at the two gaps north of that town, and separated from two detached areas on the west and one on the east. The E is being mined commercially at a number of points. At the Indiana No. 6 mine (Ce 7) the E coal is from 4 feet to 4 feet 6 inches thick, with a 1 to 2 inch parting 8 to 10 inches from the bottom. The roof is shale and very good, with 7 inches of bone between the shale and coal. The floor is clay. The D coal lies about 40 feet lower here. To the northeast of Gipsy and around Logan are the Hillsboro mines on the E coal. At the Hillsdale No. 3 at Logan (De 7) the coal is 3 feet 10 inches thick with 4½ inches of bone on top and 1½ inch parting 6 inches from the bottom. The E coal has been worked at the Martin bank ½ mile southeast of Logan (De 12); at the J. R. Smith bank (De 21); and at the Hillsdale No. 1 (De 11). The D outcrops in the road just below the last named mine. Under the Martin bank the Trojan No. 3 mine is working the B coal by a slope. The bed is 34-36 inches of coal, overlain by 4 inches of boney coal. At the Buchannon bank just north of Gipsy (Ce 14) the E coal is 46 inches thick with 6 inches of bone on top; and a 1- to 2-inch parting 6 inches from the bottom. The Trojan No. 2 mine one mile northwest of Gipsy (Ce 25) is on the D (?) coal which here is three feet thick with a bony binder one foot from the bottom. At the Hoffman bank one mile northwest of Gipsy (Ce 22) the coal is 4 feet 3 inches, with bone top 6 inches, and parting one inch thick 6 inches from the bottom. At the Alexander Gorman bank 1¼ mile west of Gipsy (Ce 23) the coal is 50 inches, including 1-inch parting of shale 7 inches from the bottom, but the top bone has thickened up to about 12 inches. The E coal extends out under the top of the ridge toward Robertsville and has been worked at Ce 1 and 2. Below the last, the D coal has been opened at Ce 3. On the road down to Robertsville the B coal outcrops at Be 5, accompanied by the Clarion flint clay; the A and the A′ coals outcrop in the road close to the bottom lands.

On the top of the ridge, one mile west of Gipsy, both the E and D coals are cut out at the gap between the two Gorman Runs. Just south of the gap is the Arcadia No. 44 (old No. 8) mine (Ce 12) which was opened in 1905. The main bench of the E coal here runs from 3 feet 6 inches to 4 feet, with 4 to 6 inches of coal below a one-inch binder. The top bone is from 8 to 10 inches thick. The D coal 22 inches thick outcrops about 30 feet below, at (Ce 11). From this point the E coal underlies the crest of the ridge in a narrow irregular belt extending out the spurs. It has been opened at the James Gorman bank (Ce 16); at the Carnahan bank (Ce 18), and at other places (Ce 17, 20 and 21).

Several of the coals outcrop on the road from Nashville to the top of the ridge. The E coal outcrops at the top of the hill three-quarters of a mile southeast of Nashville and is underlain as usual with a bed of flint clay, offering some promise at this point. At an elevation of about 1660 feet is an outcrop probably of the C′ coal, overlain with coarse-grained sandstone; at 1580 feet, an exposure of the C coal, overlain with drab and pink clay shale, the coal being at least 18 inches thick. At about 1480 feet is an old opening on what may be the A coal. This is at Nashville and about 40 feet above the creek.

On the opposite side of the ridge facing the west fork of Cush Creek the E coal has a somewhat larger body, for the axis of the anticline here lies west of the top of the ridge and the dip carries the coal down well toward the valley on the east side. The E coal has been opened at the Dubendorf bank one-half mile north of Wilgus (Cf 4), at the Arcadia No. 3 mine (old No. 4) at Wilgus (Cf 5), and at the Indiana No. 5 mine (Cf 6). At the Arcadia mine, the old A. B. Clark bank, the coal is 4 feet thick and overlain by 11 inches of bone. Here, as in many of these mines, the top or all of the bone is considered to grade into a cannel coal. At the Indiana No. 5 also, the coal is 4 feet thick, the ½-inch bony binder coming 3 inches from the bottom; the bony top here is up to 8 inches thick. The dip carries all of the coals below drainage on the north fork of Cush Creek a short distance above the Indiana No. 5 mine. To the southwest and west of this the anticline keeps the coals well up in the ridge. The E has been opened at Cf 1, 2 and 3, at the Wells bank (Bf 7), and at Mrs. Spicher's bank (Cf 8) on the head of Rairigh Run. At the Wells bank the main bench is somewhat thinner than to the north, being 27 inches, and the bone top has thickened to 14 inches. The bottom bench is 6 inches thick as usual. This condition is probably quite local, as at Mrs. Spicher's bank the coal is 42 inches all told with the bone top only 6 inches.

In the ridge between Rairigh Run and East Run, the E coal is worked at the J. A. Numann bank (Bf 8). The coal here measures only 3 feet with sandstone roof; the shale floor, 4 inches thick, overlies 18 inches to 2 feet of clay. Three-quarters of a mile east of East Run settlement the same coal has been opened by Westover and Baker (Cf 11). Here the coal has the same typical section that it shows all through the region to the northeast. The section is: bony coal, 4 to 6 inches under hard brown sandy shale; coal, 3 feet 7 inches; shale, 1 inch; coal, 4 inches; light drab clay. The dip has brought the coal down nearly to water level. The D outcrops in the road one-half mile east of East Run (Bf 9) and is reported 4 feet 4 inches thick, some 40 feet below the E coal at the mine. Just off the quadrangle, south of East Run, the E has been opened, underlain by

flint clay and the D outcrops 26 feet below. The E bed and the other Allegheny coals go below drainage to the eastward and will be found more than 200 feet below water level at Hillsdale.

In the ridge between the north and south forks of Cush Creek the E coal has been opened at the Alexander Irwin bank at Wilgus (Cf 7) where the coal is 38 inches thick, overlain by 7½ inches of bone; and at the B. Smith banks where the coal is 4 feet thick, including the one-inch shale parting 6 inches from the bottom; the coal is overlain by 5 inches of bone. Though this is a small mine the drift has been driven entirely through the hill (Ce 22-23). The E coal has been opened again at the Bennett bank three-quarters of a mile southwest of Hooverhurst (De 17) where the coal is 3 feet 10 inches thick, including one inch of shale, 3 inches from the bottom, and overlain by 4½ inches of bony coal. Around Arcadia the E coal is being extensively mined at the Arcadia No. 1 and 2 mines and the Victor No. 11 and 14 mines. The dip here brought the coal down close to water level so that it goes under drainage before reaching Victor No. 14 mine. The coal maintains its thickness through these mines, ranging up to 4 feet thick, and down to a minimum of about one foot, with an average of about 3½ feet, and with the bony top ranging to 4 inches thick.

BURNSIDE DISTRICT

Introductory statement.

The Burnside district includes the southeast corner of the quadrangle or that part of the quadrangle lying east and south of Cush Creek and of the West Branch of Susquehanna River below the mouth of Cush Creek. The West Branch of the Susquehanna River crosses the district, in a deep trench with alternating wide and narrow bottom. Between Cush Creek and the Susquehanna the ridges are flat-topped at an elevation of 1600 feet. Some of the streams have little grade in their upper courses and steep grade near the mouth. East of the Susquehanna the divide is higher and the ridge tops are narrower. The New York Central and Pennsylvania railroads enter and cross this district, and afford good transportation facilities. The Allegheny coals are below drainage under practically all of the south part of this district. The E, D and B coals are workable at least in part of the district, though but little over 2 to 2½ feet thick.

Stratigraphy.

The outcropping rocks extend from near the middle of the Conemaugh group to the top of the Pottsville series. The rocks out-

cropping between Cush Creek and Susquehanna River are practically all of Conemaugh age. The top of the Allegheny outcrops around the foot of the bluff near Glen Campbell to Dowler Junction and Burnside. East of the Susquehanna the rocks are all of Conemaugh age from the south edge of the quadrangle as far north as Burnside. There the Allegheny rises above drainage and outcrops along the flanks of the ridge below Burnside, but gradually rising to 200 feet above the river on the ridge near McGees Mills; and in the north part of the district the top of the Pottsville rises above the level of the Susquehanna.

About 350 feet of the Conemaugh group outcrop in the high hills along the axis of the Brush Valley syncline.

The stratigraphy of this district has not been worked out so clearly as in some other districts, owing to the fact that the Allegheny coals are below drainage under practically the entire district, and only a few drill holes have penetrated them, and those holes are so scattered that with the usual variation in the coals, it has not always been possible to determine the exact correlation of the coals. At the north and west the E coal is regularly present and workable. To the southeast of this area in the Barnesboro quadrangle the E coal is inconspicuous, and the D coal is the principal upper coal. In the records of some of the drill holes in this area it is difficult to decide whether the first coal encountered is the E or D. Indeed in some it would appear that both the E and D were absent. Those holes that went deep enough, encountered a fairly regular workable coal, assumed to be the B, about 200 feet below the E. In some of the holes the position of the E coal was calculated from the position of a coal supposed to be the B.

The surface rocks, like those of the Conemaugh group elsewhere in the quadrangle, contain no constant "key" rocks or coals. In some areas the top of a sandstone can be traced for a short distance, and locally and with less certainty for considerable distances. As a whole, outcrops are scarce in this district.

Allegheny group. The Allegheny group appears to have the usual thickness of about 300 feet. Most of the drill holes have gotten down only to coal considered to be the B, which is about 200 feet below the E coal. In the interval between are sandstones and shales, without any discernible regularity, and coal beds that would seem to occupy the positions of the D, C′ and C coals. Of these five coals the E appears to be workable over most of the north part of the area, and probably the west part, the thickness ranging from 2 to 4 feet with an average in that part of the district of over 3 feet. Toward the southwest corner of the quadrangle the E coal appears to become too thin to work, often only a few inches.

The D coal is of variable thickness and occurs at a variable distance below the E. At Arcadia it is from 20 to 30 feet below, averaging about 25 feet. In the southeast corner they are often only 10 to 20 feet apart. Over much of the area they appear to be 40 to 50 feet apart. The D coal here is usually less than 2 feet thick, and often less than 1 foot, though locally it reaches a thickness of 3 feet or more. It is mined at Burnside.

The C and C′ coals are usually less than 18 inches thick, in many sections less than one foot. Locally one or the other has a thickness of 2 to 3 feet and may prove to contain a small quantity of workable coal.

The B coal has a thickness of 2 feet or more in most of the drill holes. In some it is over 3 feet. In some of the drill holes there appear to be two coals at this horizon within ten feet of each other, though usually only one of them is workable. This bed will average probably 2 feet 6 inches thick.

Conemaugh group. The Conemaugh group, which forms the surface of all except the Susquehanna valley north of Burnside and the valley of Cush Creek to Arcadia, has remaining a maximum thickness of about 350 feet. An indefinite thickness has been removed by erosion. The group is composed principally of shaly sandstone and sandy shales, with a clay and coal. The first 50 feet or so above the E coal is generally shaly though in some areas it is sandy, and in the record of one drill hole is reported as a conglomerate. Near the top of this interval the Mahoning sandstone is found locally, and sometimes a few inches of coal or bone. The beds at the base of the Conemaugh group show well in a railroad cut just southwest of Burnside. Between the Mahoning coal horizon and the horizon of the Brush Creek coal is usually a sandstone which is locally quite massive. It shows in many places in the valley of the West Branch of the Susquehanna, south of Burnside and on Beaver Run in the southeast corner of the quadrangle. Its presence may explain a long stretch of level bottom land on Rock Run southwest of Burnside.

Above this sandstone a few traces of the Brush Creek coal were found, but in general the coal appears to be absent. The Brush Creek limestone is present more frequently than the coal. Above this horizon is usually 40 to 60 feet of shale. At the top of this shale is a band of red shale, which is exposed in a few localities, as at a watering trough near the top of the hill on the road west from Burnside; also on the road at the head of North Run, east of Bellnap. This is at the horizon of the "lower red shales," below the Bakerstown coal. This coal crops out at a number of points. It has been opened on a knob 1¼ miles southeast of Patchinville and is reported as 28 inches thick. Above this is commonly a sandstone, whose top

is about 280 feet above the E coal. This would appear to be in the position of the top of the Saltsburg sandstone. This sandstone makes flat benches and broad stream bottoms around Hillsdale, Bowdertown and northeast toward Rock Run and in places on the east side of the Susquehanna. It is nowhere very massive and is easily confused with a similar sandstone that appears to be about 50 feet above it. Just above the top of the Saltsburg sandstone is a coal that is persistently met with in blooms on the roads.

Above this coal is shale with another coal 20 to 50 feet above the first. These two coals are so close together stratigraphically that it is difficult in many cases to know to which of the two a given outcrop belongs, as the two are seldom seen in the same hill. Attempts to mine what is considered to be the upper of the two coals has been made southeast of Bowdertown (Df 7). Above the upper of these two coals is a sandstone that caps the ridges about a mile west of the West Branch of the Susquehanna near Patchinville; also the top of the ridge 1½ miles east of Patchinville. This sandstone appears to be about at the position of the Morgantown. On that basis the lower of the two coals just mentioned may be the Harlem and the higher the Barton coal.

Structure.

The Brush Valley syncline passes through the middle of this district in a northeast-southwest direction, and as a result the various strata are low as compared with the elevation in other districts. Thus on the axis of the syncline two miles east of Bowdertown the E coal is only about 1250 feet above sea level, rising to 1300 feet just east of Burnside. From 1250 feet on Shryock Run the E rises to the northwest to 1450 feet at Arcadia. It has about the same elevation on Cush Creek at Glen Campbell, and is a little lower at Cush Creek Junction. Toward the north end of this district the rise carries the E coal well into the hills at an elevation of 1550 feet above sea level and near McGees Mills it would be at 1600 feet if not eroded. In the southeast corner of the quadrangle the E coal rises to the east to 1400 feet above sea level. The B coal should be found about 200 feet lower than the E all through this district.

Coal beds.

The coals of the Allegheny group are entirely below drainage in this district except in the lower part of Cush Creek Valley and the valley of West Branch of Susquehanna River below Burnside. The E and D coals outcrop around the north end of the area between Cush Creek and West Branch of Susquehanna River and all the coals

are brought to daylight on the east side of the river toward the north end of this district, around McGees.

The E coal around Arcadia and to the north has the same general section as in the Gipsy district to the west—that is, a bench a few inches thick at the base, then a parting 1 to 5 inches thick, then a main bench of coal with bony coal on top.

Just south of Glen Campbell are the Indiana No. 1 (Ee 9) and 7 (Ee 10) mines on what is believed to be the E coal. The coal there shows the bottom bench 3 or 4 inches thick, then a parting from 6 to 15 inches thick, then in the case of the No. 1 mine 30 inches of coal separated from 18 inches of coal above by 3 to 4 inches of cannel or bony coal. Still above that are 7 inches of shale, 2 inches of coal and 6 inches of bony or cannel coal. At the No. 7 mine are: first, (from the bottom) 4 inches of coal, 12 to 18 inches of clay, 6 inches of coal, 6 inches of clay, then a main bench, 24 to 33 inches of coal. Half a mile below the mouth of Brady Run (Ee 15) the E coal is reported to contain 5 inches of coal in the bottom bench and 17 inches of coal in the top bench separated by 5 inches of shale. The D coal at this point is reported as 28 inches thick. At the Eliza White mine (Ec 16) the E coal was reported to show 28 inches of coal at the bottom, 2 inches of parting, 13 inches of coal and 6 inches of bone. At the Gardner bank (Ec 21) ½ mile south of Dowler Junction the coal shows a bottom bench 24 inches, parting 3 inches, middle bench 10 inches, parting 3 inches, upper bench 10 inches. West of Burnside are the Empire G mine (now Glenwood No. 14) and the Glenwood Spring No. 10 mine (Ee 18 and 17) at elevations of 1363 and 1351 feet, respectively. At the former the coal measured: bottom bench, 19 inches; sandstone parting, 2 inches; middle bench, 18 inches; parting, 2 inches; top bench, 16 inches; over which is one foot or less of bony coal with a shale roof. Just northeast of Burnside is the John Patchin bank (Fe 6), where the E coal shows: coal, 31 inches: parting ½ inch to 0; middle bench, 4 inches; parting, ½ inch, upper bench, 2 inches; and shale roof. South of that point all the coals are below drainage, while to the north the E and D coals gradually climb toward the top of the hill. One mile northeast of Bellnap and about 100 feet above the river is the Mount Airie mine on the E coal. Under a strong shale roof is one or two inches of bony coal, a main bench 2 feet 8 inches thick, a 1-inch parting, and a bottom bench of 4 to 6 inches of coal. The mine is equipped with electricity and all coal cut by machine.

In the railroad cut on the New York Central just south of where it crosses the river (Fd 1) is an exposure of the C coal showing a lower bench of 10 inches and upper bench of 24 inches, separated by 15 inches of black shale. The same coal on the north side of the river

(Fd 4) is 28 inches thick under a sandstone roof. In general the E coal is workable under most of the district, ranging from 2 to 4 feet in thickness, though apparently thin in the southeast corner of the district. The D coal appears to be thin in most of the district, usually under 3 feet and often showing only a few inches, or is absent altogether, though in a few sections showing 2 feet or more and up to 2 feet 9 inches locally. The Lower Kittanning or B coal in most sections shows a workable thickness, usually over 2 feet and up to 3 feet or a little over. Toward the southeast this bed appears to be split into two benches and locally both benches are workable. The A coal is 4 feet thick around McGees on the north side of the river, and though not seen in the Burnside district may be assumed to maintain a workable thickness under at least part of the north end of the district.

In addition to the Allegheny coals already mentioned the map shows the outcrops of coals in the Conemaugh formation at the Bakerstown and Harlem horizons. These coals reach a thickness of 18 inches in places and may be found locally to be even thicker, but as a rule, cannot be classed at present as workable coals. The Bakerstown coal is about 230 feet above the E, the Harlem coal 40 to 50 feet higher.

COAL RESERVES.

Method of computing.

In the following table are shown the approximate acreage of each township or that part of it included in this quadrangle. Under each township is given the area within that township (within the quadrangle) underlain by each of the principal coal beds. These areas were determined by placing cross section paper over the map showing the coal outcrops. The cross section paper was divided into 64 squares to the square inch, each square being equal to 10 acres on the map having a horizontal scale of one mile equals one inch. The squares were counted if more than half underlain by the coal bed and rejected if less than half underlain. This method is probably as accurate as the accuracy of the outcrop lines would warrant.

Then all the measurements in a given coal bed in a township were brought together, including those from mines, outcrops, and drill records. The latter, in some instances, far outnumbered the former. These were then divided into three groups: those over two feet; those between two feet and one foot; and those under one foot in thickness. In recording these thicknesses the net thickness only was used; that is, the thickness left after rejecting any minor benches separated from the main bench by a parting of greater thickness than the coal bench or if the parting was thinner than coal bench, there was added to the thickness of the major bench only the differ-

ence in thickness of the minor bench and the parting. The purpose of such procedure is, if possible, to use such a measurement as would, if it represented solid coal, be about equivalent to the split-up bed. Two examples will illustrate the method. For example, coal section No. 5, figure 7 reads: bone coal, 5″; coal, 16″; bone coal, 5″; coal 9″; a total of 35″. Obviously this is not equal to a 35″ bed of solid coal. Rejecting the 5-inch layer of bone coal at the top, the remainder is still not equal to a 30-inch bed of solid coal. As the bottom 9-inch bench of coal is thicker than the overlying 5-inch band of bone coal, it may pay to work. If so, the bed as a whole is worth more than a 16-inch bed of coal. It has seemed that an arbitrary rule of subtracting the 5-inch from the 9-inch and adding the 4-inch remaining to the 16-inch of the major bench would be both a fair and simple rule. That bed is treated then as equivalent to a 20-inch bed. The "net thickness" of section 19, figure 7 would be computed by adding to the thickness of the main bench (24″), 4 inches for the middle bench (6″ - 2″) and 14 inches for the upper bench (18″ - 4″), so that while the bed actually contains 4 feet of coal it is assumed to be equivalent in value to a solid bed 42 inches thick.

Returning to the three groups of sections—first, the average was obtained of all of those over 2 feet thick and this, reduced to the next lower ¼ of a foot, is given in the column under the head of "coal more than 2 feet thick." An average thickness of 18 inches was assumed for the coals between one and two feet thick unless a large number of sections indicated a lower or higher average. Then an estimate was made of the proportion of the area underlain by coal over 2 feet thick, by coal between 1 and 2 feet and by coal under one foot or where lacking entirely. These figures are quite arbitrary and, doubtless, with the same data, would hardly be estimated exactly alike by any two persons or even by the same person at two different times. Where the data were mainly drill records, the proportion of a given area assigned to one of the three thicknesses has been determined by the proportion of measurements in the three groups. For example, in a particular case, a certain bed in one of the townships underlies 5400 acres. Of the 18 measurements on that bed, 4 were less than one foot thick, 8 between one and two feet thick, and 6 over 2 feet. Accordingly, the acreage was divided into 1800 acres as underlain by coal over 2 feet thick, and 2400 acres as underlain by coal between one and two feet thick, and 1200 acres as containing no coal at that horizon or as underlain by coal below one foot in thickness.

In general, the data used were measured sections, partly from commercial mines, partly from neighborhood openings. Experience has shown that these measurements average as a rule above the

average of the district, for the reason that the commercial mines are usually located only after a study of the field and in the areas of the thickest and best coal. In like manner, openings made by farmers are kept open only if the coal is of fair thickness. Openings made where the coal proves to be thin are allowed to fall shut again and are soon forgotten. For this reason, in estimating the area assumed to be underlain by the three different thicknesses, a general knowledge of the bed is taken into consideration, as well as knowledge of local conditions. Thus, in the Punxsutawney quadrangle, the B coal is exposed in only a few areas. Several measurements around McGees and Mahaffey indicate a thickness of a little under two feet with a tendency to thicken away from that area,—the thickness apparently ranging around 3 feet near Glen Campbell and in North Bell township, Clearfield County, and in the upper waters of Little Mahoning Creek. It might be assumed, therefore, that the B bed in this area ranges from 3 feet to a little less than 2 feet in thickness and the area divided up accordingly.

Where, as in this instance, local data are scarce, conservative figures have been assumed which it is felt will probably be within the truth. For that reason the figures for the areas assumed to be underlain by coal less than one foot thick are large for some of the beds even though, in many of the townships, no measurements of such thin coal were obtained. In the table, this figure in any township is the difference between the total area underlain by the coal and the area assumed to be underlain by coal more than one foot thick. Thus, in McGilpin township there are assumed to be 300 acres of E coal, averaging 2½ feet thick, 200 acres averaging one foot thick, and the remainder (320 acres) is assumed to be underlain by coal less than one foot thick or to be entirely lacking in coal.

In determining the area of very thin coal, that is, less than one foot thick, account is taken of any known local conditions, such as channels which cut out the coal, and the general regularity or irregularity of the beds as determined by a study of the variations over a wide area. Thus, the usual regularity of the E and B beds has been recognized in making the estimates. The writer has had opportunity to study each of those beds where exposed more or less continously for several miles in railroad cuts, as in valleys following the strike of the rocks. The other four beds, on the contrary, are characteristically variable and added allowance of thin and very thin coal has been made in the case of those beds.

The line has been drawn between coal beds one foot and those less than one foot thick, and between those two feet or more and those less than two feet, on the assumption that coal beds less than one foot thick may not be considered of any value at the present time

or in the near future, while the coal beds between one and two feet thick may be classed as reserves hardly workable under present conditions except in connection with the working of the underclay or the overlying shale or other rock. Coal beds more than two feet thick are assumed to be minable at present or will be in the very near future. The lower limit of workability has steadily decreased from 4 or 5 feet, in the early days of mining in this region, to 2 feet or 2½ feet at the present time. Indeed some commercial mining has been done on coals that ran below 24 inches thick, where the average of the mine was above that figure.

The township is made the unit of area in computing reserves in the belief that the most frequent demand for such figures will be by counties and townships. The figures in the following table represent only that part of each township that is in the Punxsutawney quadrangle. No allowance has been made for coal mined out. The estimates are based on 1800 tons per acre-foot.

Coal Reserves in the Punxsutawney Quadrangle, in short tons

Counties Townships Coal beds	Total acreage (within quadrangle)	Coal between 1 and 2 ft. thick			Coal more than 2 feet thick			
		Average thickness	Acreage	Total tonnage	Average thickness	Acreage	Total tonnage	Net tonnage
JEFFERSON CO.								
McCalmont twp.	1,130		200	360,000	2′ 6″	300	1,350,000	750,000
E coal	820	1′ 0″			2′ 0″	300	1,080,000	600,000
D "	900				6′ 0″	300	3,240,000	1,800,000
C′ "	1,060	1′ 0″	300	540,000	2′ 6″	300	1,350,000	750,000
C "	1,090	1′ 6″	500	1,350,000	2′ 0″	200	700,000	400,000
B "	1,130	1′ 6″	500	1,350,000	3′ 0″	300	1,620,000	900,000
A "	1,130	1′ 6″	500	1,350,000				
Totals,				4,950,000			9,340,000	5,200,000
Young twp.	8,610							
E coal	7,480	1′ 6″	3,000	8,100,000	3′ 0″	2,000	10,800,000	6,000,000
D "	7,960	1′ 6″	2,000	5,400,000	6′ 0″	3,000	32,400,000	18,000,000
C′ "	8,260	1′ 0″	3,000	5,400,000	2′ 6″	3,000	13,500,000	7,500,000
C "	8,500	1′ 6″	4,000	10,800,000	2′ 0″	2,000	7,200,000	4,000,000
B "	8,570	1′ 6″	4,000	10,800,000	3′	4,000	21,600,000	12,000,000
A "	8,610	1′ 6″	4,000	10,800,000				
Totals,				51,300,000			85,500,000	47,500,000
Bell twp.	12,330							
E coal	11,970	1′ 6″	3,000	8,100,000	3′ 0″	5,000	27,000,000	15,000,000
D "	12,160	1′ 6″	4,000	10,800,000	4′	4,000	28,800,000	16,000,000
C′ "	12,330	1′ 0″	4,000	7,200,000	2′ 6″	4,000	18,000,000	10,000,000
C "	12,330	1′ 6″	5,000	13,500,000	2′ 0″	3,000	10,800,000	6,000,000
B "	12,330	1′ 6″	5,000	13,500,000	3′ 0″	7,000	37,800,000	21,000,000
A "	12,330	1′ 6″	5,000	13,500,000				
Totals,				66,600,000			122,400,000	68,000,000
Gaskill twp.	13,780							
E coal	5,370	1′ 6″	1,500	4,050,000	3′	3,500	18,900,000	10,500,000
D "	7,470	1′ 6″	3,000	8,100,000	3′	2,000	10,800,000	6,000,000
C′ "	9,210	1′ 0″	2,000	3,600,000	2′ 6″	1,000	4,500,000	2,600,000
C "	10,950	1′ 6″	3,000	8,100,000	2′ 0″	2,000	7,200,000	4,000,000
B "	12,690	1′ 6″	6,000	16,200,000	2′ 6″	6,000	27,000,000	15,000,000
A "	13,780	1′ 6″	4,000	10,800,000	2′ 6″	1,000	3,600,000	2,000,000
Totals,				50,850,000			72,000,000	40,100,000

Henderson twp.	6,170+							
E coal	5,400	1′ 6″	2,400	6,480,000	2′ 6″	1,800	8,100,000	4,500,000
D "	5,730	1′ 6″	1,000	2,700,000	3′ 6″	3,000	18,900,000	10,500,000
C′ "	5,880	1′ 0″	1,000	1,800,000	2′ 6″	500	2,250,000	1,250,000
C "	6,030	1′ 6″	2,000	5,400,000	2′ 0″	1,000	3,600,000	2,000,000
B "	6,160	1′ 6″	3,000	8,100,000	2′ 6″	3,000	13,500,000	7,500,000
A "	6,170	1′ 6″	3,000	8,100,000				
Totals,				32,580,000			46,350,000	25,750,000
INDIANA CO.								
Banks twp.	21,460							
E coal	4,310				3′ 9″	4,000	27,000,000	15,000,000
D "	7,820	1′ 6″	3,000	8,100,000	4′ 3″	4,000	30,600,000	19,000,000
C′ "	11,530	1′ 6″	5,000	13,500,000	2′ 6″	2,000	9,000,000	5,000,000
C "	15,240	1′ 6″	5,000	13,500,000	2′	2,000	7,200,000	4,000,000
B "	18,950	1′ 6″	5,000	13,500,000	3′ 6″	5,000	31,500,000	17,500,000
A "	20,700	1′ 6″	5,000	13,500,000	3′ 6″	5,000	31,500,000	17,500,000
Totals,				62,100,000			136,800,000	78,000,000
Canoe twp.	18,560							
E coal	10,170	1′ 6″	2,000	5,400,000	4′	8,000	57,600,000	32,000,000
D "	12,720	1′ 6″	4,000	10,800,000	3′	4,000	21,600,000	12,000,000
C′ "	14,250	1′ 6″	10,000	27,000,000				
C "	15,780	1′ 6″	12,000	32,400,000				
B "	17,320	1′ 6″	10,000	27,000,000	3′	5,000	27,000,000	15,000,000
A "	17,910	1′ 6″	10,000	27,000,000				
Totals,				129,600 ,000			106,200,000	59,000,000
N. Mahoning twp.	1,470							
E coal	1,340	1′ 6″	400	1,080,000	4′	800	5,760,000	3,200,000
D "	1,390	1′ 6″	400	1,080,000	3′	400	2,160,000	1,200,000
C′ "	1,470	1′ 6″	1,000	2,700,000				
C "	1,470	1′ 6″	1,200	3,240,000				
B "	1,470	1′ 6″	1,000	2,700,000	3′	300	1,620,000	900,000
A "	1,470	1′ 6″	1,000	2,700,000				
Totals,				13,500,000			9,540,000	5,300,000
E. Mahoning twp.	800							
E coal	80				3′ 6″	80	504,000	280,000
D "	190	1′ 6″	100	270,000	2′ 6″	50	225,000	127,500
C′ "	360	1′ 6″	200	540,000	2′ 9″	100	495,000	275,000
C "	530	1′ 6″	300	810,000	2′	200	720,000	400,000
B "	730	1′ 6″	300	810,000	2′ 9″	400	1,980,000	1,100,000
A "	800	1′ 6″	400	1,080,000	2′	200	720,000	400,000
Totals,				3,510,000			4,644,000	2,582,509
Grant twp.	14,320							
E coal	4,240				3′ 6″	4,000	25,200,000	14,000,000
D "	6,030	1′ 6″	4,000	10,800,000	2′ 6″	2,000	9,000,000	5,000,000
C′ "	8,170	1′ 6″	5,000	13,500,000	2′ 9″	1,000	4,950,000	2,750,000
C "	10,130	1′ 6″	6,000	16,200,000	2′	1,500	5,400,000	3,000,000

Coal Reserves in the Punxsutawney Quadrangle, in short tons—Continued

Counties Townships Coal beds	Total acreage (within quadrangle)	Coal between 1 and 2 ft. thick			Coal more than 2 feet thick			
		Average thickness	Acreage	Total tonnage	Average thickness	Acreage	Total tonnage	Net tonnage
B "	12,450	1′ 6″	8,000	21,600,000	2′ 9″	4,000	19,800,000	11,000,000
A "	14,140	1′ 6″	5,000	13,500,000	2′	2,000	7,200,000	4,000,000
Totals,				75,600,000			71,550,000	39,750,000
Montgomery twp.	14,280							
E coal	12,110	1′ 6″	4,000	10,800,000	3′ 6″	8,000	50,400,000	28,000,000
D "	12,950	1′ 6″	4,000	10,800,000	2′ 9″	5,000	24,750,000	13,750,000
C′ "	13,390	1′ 6″	8,000	21,600,000	2′ 9″	2,000	9,900,000	5,500,000
C "	13,830	1′ 6″	8,000	21,600,000	2′	2,000	7,200,000	4,000,000
B "	14,280	1′ 6″	9,000	24,300,000	3′ 0″	5,000	27,000,000	15,000,000
A "	14,280	1′ 6″	5,000	13,500,000	2′	2,000	7,200,000	4,000,000
Totals,				102,600,000			126,450,000	70,250,000
CLEARFIELD CO.								
Brady twp.	900							
E coal	380	1′ 6″	100	270,000	3′ 0″	200	1,080,000	600,000
D "	560	1′ 6″	200	540,000	2′ 6″	300	1,350,000	750,000
C′ "	680	1′ 6″	400	1,080,000	2′	100	360,000	200,000
C "	800	1′ 6″	400	1,080,000	2′	200	720,000	400,000
B "	900	1′ 6″	300	810,000	2′ 6″	300	1,350,000	750,000
A "	900	1′ 6″	200	540,000	2′	200	720,000	400,000
Totals,				4,120,000			5,580,000	3,100,000
Bell twp.	18,700							
E coal	3,610	1′ 6″	1,000	2,700,000	2′ 6″	2,000	9,000,000	5,000,000
D "	6,080	1′ 6″	2,000	5,400,000	2′ 6″	3,000	13,500,000	7,500,000
C′ "	8,850	1′ 6″	4,000	10,800,000	2′	1,000	3,600,000	2,000,000
C "	11,620	1′ 6″	6,000	16,200,000	2′	2,000	7,200,000	4,000,000
B "	14,400	1′ 6″	6,000	16,200,000	2′ 6″	8,000	36,000,000	20,000,000
A "	17,840	1′ 6″	6,000	16,200,000	3′ 9″	4,000	27,000,000	15,000,000
Totals,				67,500,000			96,300,000	53,500,000
Burnside twp.	12,550							
E coal	11,100	1′ 6″	5,000	13,500,000	3′	3,000	16,200,000	9,000,000
D "	11,870	1′ 6″	5,000	13,500,000	2′ 6″	4,000	18,000,000	10,000,000
C′ "	12,090	1′ 6″	9,000	24,300,000	2′ 6″	1,000	4,500,000	2,500,000
C "	12,310	1′ 6″	9,000	24,300,000	2′	1,000	3,600,000	2,000,000
B "	12,550	1′ 6″	5,000	13,500,000	2′	5,000	18,000,000	10,000,000
A "	12,550	1′ 6″	5,000	13,500,000	2′	1,000	3,600,000	2,000,000
Totals,				102,600,000			63,900,000	35,500,000

Summary Table.

Counties / Townships	Total by townships		
	Reserves Coal between 1′ and 2′ thick	Available coal Coal over 2′ thick	
	Total tonnage	Total tonnage	Net tonnage (100 tons to acre-foot)
Jefferson County (part)			
McCalmont twp. (part)	4,950,000	9,340,000	5,200,000
Young twp (part)	51,300,000	85,500,000	47,500,000
Bell twp.	66,600,000	122,400,000	68,000,000
Gaskill twp.	56,850,000	72,000,000	40,100,000
Henderson twp. (part)	32,580,000	46,350,000	25,750,000
Totals,	206,280,000	335,590,000	186,550,000
Indiana County (part)			
Banks twp.	62,100,000	136,800,000	78,000,000
Canoe twp.	129,600,000	106,200,000	59,000,000
N. Mahoning twp. (part)	13,500,000	9,540,000	5,300,000
E. Mahoning twp. (part)	3,510,000	4,644,000	2,582,500
Grant twp. (part)	75,600,000	71,550,000	39,750,000
Montgomery twp. (part)	102,600,000	126,450,000	70,250,000
Totals,	386,910,000	455,184,000	254,882,500
Clearfield County (part)			
Brady twp. (part)	4,120,000	5,580,000	3,100,000
Bell twp (part)	67,500,000	96,300,000	53,500,000
Burnside twp. (part)	102,600,000	63,900,000	35,500,000
Totals,	174,220,000	165,780,000	92,100,000
Totals for quadrangle	767,410,000	956,554,000	533,532,500
	1,723,964,000		

Summary of coal by thickness, in short tons.

Thickness	Quantity	Percentage
Less than 2 feet	767,410,000	43
Between 2 and 3 feet	360,970,000	20
Between 3 and 4 feet	437,184,000	25
Between 4 and 5 feet	122,760,000	7
Over 5 feet	35,640,000	2
Total	1,723,964,000	

HISTORY OF MINING.

When this area was first examined by the Second Geological Survey no railroads entered or crossed the quadrangle, and no coal was shipped. A number of country banks providing coal for local use were scattered here and there, notably north and northwest of Punxsutawney. When Jefferson County was reexamined in 1881, the area was still without railroads or commercial mining. The Buffalo, Rochester & Pittsburgh Railway was built and commercial mining began around Punxsutawney in 1882 and 1883.

This route and the Pennsylvania Division of the New York Central Lines have given the coal of the Punxsutawney quadrangle access to the market in central and western New York State and in New England. A division of the Pennsylvania Railroad also carries the coal to New York City and New England. See Figure 26.

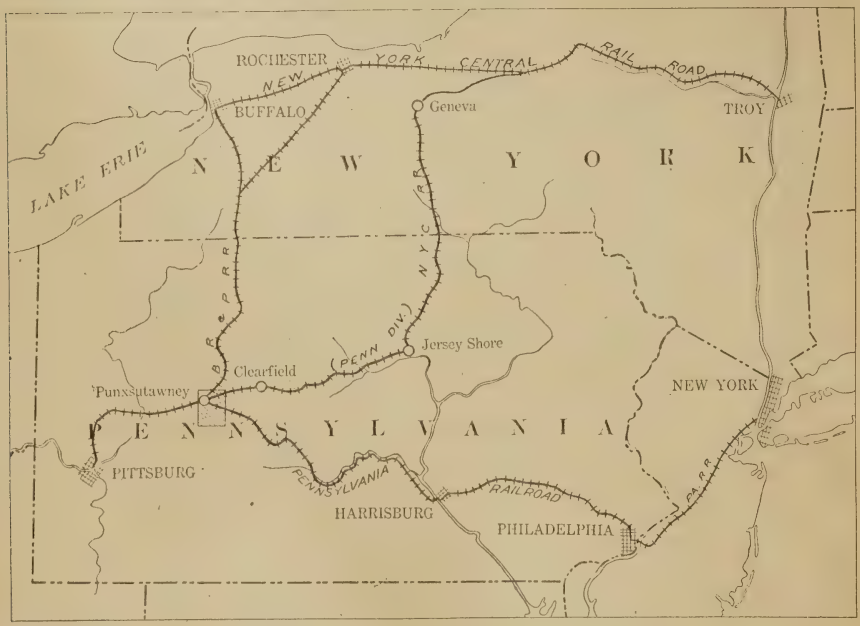


FIGURE 26. Sketch map showing railroad transportation from the Punxsutawney district.

In 1889, according to the State Mine Inspector's report for that year, there were in operation at Punxsutawney the Walston mines Nos. 1, 2 and 3, Adrian mines Nos. 1, 2 and 3, and Eleanora mine No. 1, the last lying a little north of the quadrangle. The Walston No. 1 was even then approaching exhaustion. In addition to these, the report of 1891 mentions five mines near Glen Campbell: the Penn of Riekert Brothers; Glenwood Nos. 3 and 4, of the Glenwood Coal Company; and Urey Nos. 1 and 2, of Passmore & Company. Dur-

ing the 10 years from 1890 to 1900 mining continued in the districts already noted, a number of new mines were opened, and mining began at Rossiter (in 1900), at Horton Run, Burnside, and Arcadia. Since then mining has been started on Clover Run and near Richmond.

The mines near Punxsutawney have been large producers. For a number of years the Rochester & Pittsburgh Coal & Iron Company's group of mines north and northwest of Punxsutawney yielded over 3,000,000 tons of coal a year. By 1905 the Canoe Ridge mines were yielding nearly 1,000,000 tons yearly. The output of all of these large mines fell off steadily during the decade from 1905 to 1915. In 1913, however, Adrian No. 1 was still producing almost 500,000 tons, the Eleanora shaft over 600,000 tons, the Florence mines nearly 500,000 tons, and the Helvetia-Stanley mine, just west of the quadrangle over 500,000 tons, while the Canoe Ridge mines produced nearly 650,000 tons. The Arcadia mines, the same year, produced nearly 400,000 tons. At that time the Walston mines were nearly exhausted. The mines north of Punxsutawney were connected so that Florence, Scholler, Adrian, and Walston No. 3 all drained to the Elk Run shaft, where the water was lifted by large Jeansville pumps.

By 1921 the Adrian and Elk Run mines were down to less than 200,000 tons, Eleanora less than 100,000 tons, and the Walston mines had practically finished production. The Rossiter group of mines was still producing over 300,000 tons of coal a year, Victors Nos. 11 and 14 were producing over 100,000 tons. Of the other mines the following produced over 40,000 tons during either 1921 or 1922: Adrian No. 5, Juneau No. 1, Frances mines, Onondago shaft, Big Run mines, Bowersville, Williams Run mines, McClure and Tyson, Superior mines, Banks mines. As 1921 and 1922 were years of small productions it is probable that in other years many other mines would show a production in excess of 40,000 tons per year.

The following table originally consisted of the mines operating at the time the field work for this report was done. This was later supplemented by observations during several trips across the area. As now presented it contains in addition, the names of many mines opened since the field was personally visited by the writer. This data was furnished by Mr. T. J. Lewis, State mine inspector for the twelfth bituminous district. The mines on which data was so supplied are indicated by an asterisk. In several instances the correlation of coal beds has been changed. When so changed a question mark follows. It is probable that some of the mines listed, which were active 20 years ago, have since been abandoned, or appear under a different name.

List of commercial mines in the Punxsutawney Quadrangle.

Operating Company	Name of mine	Map reference	Figure section	Bed	Thickness	Elevation
Altoona Coal Co.	Banks No. 1	Af 2	10–106	C	3′4″–15′	1,670
Banks Coal Co.	Banks No. 1	Ec ?		A?*	4′	1,661
	Banks No. 2	Ed		A?*	4′	1,661
	Banks No. 3	Dd		A	3′7″	1,600?
	Banks No. 4	Dc		A	3′9″	1,690?
Bear Run Coal & Coke Co.	Bear Run No. 1	Ec 4	13–146	A	4′6″	
	Bear Run No. 2	Ed 1	13–155	A	3′—4′	
Beccaria Coal Co. (McGee)	Standard No. 1	Fc 4	14–149	A	4′	1,380?
Beech Creek Coal & Coke Co. See Penna. Coal & Coke Co.						
Bellefonte Coal Co.	Penna No. 2			E	3′6″–4′	
See Hudson Coal Mining Co.						
Bowers Bros. (see next)	Hillman	Dd 5	7–22	E	3′3″–4′10″	
Bowersville Coal Mining Co.	Bowersville No. 1	Db 5	7–22	E*	4′2″	1,756
Buffalo & Susquehanna Coal Co. See Onondago Coal Mining Co.						
Carrick Coal Company,	Carrick No. 1	Aa ?		D*	5′	1,610
Chestnut Ridge Coal Co. (Gypsy Coal Co. Patchin Coal Mining Co.)	Indiana No. 6 (See Patchin No. 4)	Ce 7	8–60	E	3′9″	1,765
Clark Bros. Coal Co. See Susquehanna Fuel Co.						
Clark, H. E. (Indiana Coal Co.)	Indiana No. 1	Ee 9	9–105	D	1′4″–6′	1,391
	Indiana No. 2	De 10		B	1′4″–4′	1,450
	Indiana No. 3	De 9	8–41	E	3′6″–4′5″	1,723
	Indiana No. 4	De 25		B		1,571
	Indiana No. 8	De 16		E		1,700?
	Indiana No. 5	Cf 6	8–50	E	4′	1,671
Clearfield Bituminous Coal Corp. (formerly Canoe Ridge mines)	Rossiter No. 1	Bc 5	7–24	E	3′8″–5′	1,364
	Rossiter No. 2	Bc 9		E	3′8″–5′	
	Rossiter No. 3	Bc 6		E	3′8″–5′	1,364
	Rossiter No. 4	Bc 10		E	3′8″–5′	1,375
	Rossiter No. 5			E	3′8″–5′	1,425
Clover Run Coal Mining Co.	Arthur No. 1			E	2′6″	2,010
Cushake Coal Mining Co.	Cushake	Ee		E?	3′8″	
Electric Coal Co.	Electric No. 7	Ee 16		E?	4′	1,400?
	Electric No. 8	Ee 15		E?	4′	1,425?
Ellsworth-Durham Coal Co.	Victor No. 11	Df 3		E	1′4″	1,460
	Victor No. 14	Df 4		E	1′ —4′	1,417?
Glenwood Coal Co.	Glenwood No. 3	Ee 1	9–91	D	5′2″	
	Glenwood No. 4	De 4		D	4′3″	
	Glenwood No. 5	De 5	9–90			1,629
	Glenwood No. 6	De 3	9–87	D	3′ —4′6″	
	Glenwood No. 6½	De		E	3′6″–4′	
	Glenwood No. 9			D	4′3″–4′10″	
	Glenwood No. 9½	Ee 2		D		
	Glenwood No. 10	Ee		E?	3′4″?	1,351
	Glenwood No. 11	Dd 11	8–35	E	4′4″	1,815
	Glenwood No. 12	Dd 23		D		
	Glenwood No. 14	Ee 18		E?*	3′4″?	1,363
Hammock Coal Co. (See Sawyer Coal Co.)	Cherry Grove	Cc 3	7–10	E	3′4″	
Hess Coal Co.	Hess	Ad ?		E*	4′	1,400
Hillsdale Coal & Coke Co.	Hillsdale No. 1	De 11	8–57	E	4′2	1,758
	Hillsdale No. 2					
	Hillsdale No. 3	De 7	8–56	E	4′2	1,756
	Hillsdale No. 4-7	Ce 14	8–58	E	4′2	1,845
Hudson Coal Mining Co.	Winslow	Dc 1		E	3′6″–4′	1,700
Jacobs & Delaney Coal Co.	Jacobs No. 1			A*	4′	1,465?
Juneau Coal Mining Co.	Juneau No. 1	Bc 1		E*	3′5″	1,355
Kanma Coal Mining Co.	Emlou No. 1	Ec		A	4′	1,694
Keystone Fuel Co.	Keystone No. 1			A?*	4′	1,620
Kuntz and Rinn	Dewey	Aa 23		D	3′ –6′	
Locust Colliery Co.	Locust No. 1	Ad 11		E	3′5″	1,425
Lost Run Coal Mining Co.	Mahaffey			*	2′10″	
Madeira-Hill Coal Mining Co.	Clover Run No. 1	Fb 7	8–44	E	2′5″	2,130?
	Clover Run No. 2	Fb 6	9–81	D	2′2″	2,065
	Clover Run No. 3	Fb 21		E	2′6″	2,123
	Clover Run No. 4	Fb 22		E	2′2″	2,075
	Clover Run No. 5	Fb 18		E		2,052
	Clover Run No. 6	Fb 20		D		2,063
	Clover Run No. 7	Fb 17		E		2,048
	Clover Run No. 8	Fb 19		D		2,065
	Clover Run No. 9	Fb 14		E		2,003
	Clover Run No. 10	Fb 16		D		1,992
	Clover Run No. 12	Fb 13		E		1,967

List of commercial mines in the Punxsutawney Quadrangle—Continued.

Operating Company.	Name of mine.	Map reference.	Figure section.	Bed.	Thickness.	Elevation.
Madeira-Hill Coal Mining Co.	Clover Run No. 14	Fb 12		D		1,999
	Clover Run No. 16	Fb 15		D		1,980
McClure Mining Co.	McClure	Da 6		E*	2′8″	1,334
McClure & Tyson Coal Co.	Big Run No. 1	Da 5	7–15	E	3′0″	1,500
	Big Run No. 2	Da		E*		
	Big Run No. 3	Da		F*		
McGee Coal Co.	McGee			A	4′	
See Beccaria Coal Co.						
McLeavey, John & Co.	Conrad	Aa 10	7–4	E	4′6″	
	Sholler			D	4′6″–6′	
Mount Airie Coal Co.	Mt. Airie No. 1	Fd		E*	3′0″	1,470
Onondago Coal Mining Co.	Onondago	Ca 4	7–8	E	4′	1,013
Pantell Coal Co.	Pantell	Fd		*	2′6″	1,464
Patchin Coal Mining Co.	Patchin No. 2	Fe		*		
(No. 4—old Indiana No. 6)	Patchin No. 4	Ce 7	7–60	E	3′9″	1,765
	Patchin No. 7	Ce		*	5′	1,600
Penna. Coal & Coke Corp.	Pardee No. 40	De 19		E	2′6″	1,496
(Formerly Beech Creek Coal &	Pardee No. 41	Df 2		E	3′2″–4′2″	1,445
Coke Co. with Arcadia mines).	Pardee No. 42	Df 1		E	3′ plus	1,485
	Pardee No. 43	Df 5	7–49	E	3′ –4′	1,680
	Pardee No. 44	Ce 12	7–48	E	4′6″	1,772
	Arcadia No. 5	Ce 13	7–61	E	4′	1,740?
Penn Fuel Company	Penn No. 1 & 2	Ed		E?*	4′	1,700
Pratt Coal Co.	Pratt No. 1	Cc		E*	4′	1,700
Punxsutawney Coal Mining Co.	Frances No. 1	Bc 8		E	3′2″–4′	1,406
	Frances No. 2	Cc		E	4′	1,604
	Frances No. 3	Cc		E	5′	1,716
Purage Coal Co.	Pine Hill No. 1	Ed		A?*	4′	1,560
Rochester & Pittsburgh Coal &						
Iron Co.	Adrian No. 1	Aa 12	9–72	D	4′ –7′	1,301
	Elenor Run Shaft	Ca 1	9–75	D	10′	1,055
	Elk Run Shaft	Ab 2	9–71	D	5′ –8′	1,071
	Walston No. 2	Aa 25		D	2′6″–7′	
	Walston No. 3	Aa 25	9–70	D	4′ –8′	
Rinn, S. A., Co.	Adrian No. 2	Aa 0		D		
	Adrian No. 5			D	5′	1,460
	Walston No. 1	Aa 24	9–69	D	0′ –10′	
Savan Coal Co.	Savan No. 1	Ae 16	7–32	E	4′	1,450?
Sawyer Coal Co. (Hammock)	Sawyer	Ce 3		E	3′4″	1,600
South Branch Coal Co.	Shadyside	Fe		B	3′4″	1,679
Superior Coal Co.	Superior No. 1	Dd 2	13–154	A	4′4″–5′	1,624
	Superior No. 2			?*	4′	1,775
Susquehanna Fuel Co.	Falcon No. 5	De 21				
	Falcon No. 6	De 22				
	Falcon No. 8			E?	4′	1,354
	Falcon No. 9			D?	3′	1,314
Trojan Coal Mining Co.	Trojan No. 2	Ce 25		D?*	3′	
	Trojan No. 3	De 22		B?*	3′	1,400
Urey Ridge Coal Co.	Urey No. 1	Ed 8	9–94	D	4′	1,654
	Urey No. 2	Fd 9	9–96	D	8′8″	1,562
	Urey No. 3	Ee 5		D	4′	1,440?
	Urey No. 4					
	Urey No. 5	Ee 3	9–93	D	4′6″–4′10″	
	Urey No. 6				5′	1,680
Victor Coal Co.	Empire G.	Ee 22		D	2′ –4′	1,351
(See Glenwood Coal Co.)						

*Mines not visited by writer, data furnished by Mine Inspector T. J. Lewis.

WATER RESOURCES.

In this chapter will be discussed first, precipitation in the area with reference to growth of crops and as a source of water supply; second, surface waters, their quantity, quality and seasonable variation; third, the ground waters; fourth, present sources of private and public water supplies; fifth, water power. The topography and drainage have already been discussed and are shown on the map.

PRECIPITATION

The following table shows fairly well the average and seasonal precipitation in this area. The figures are not of equal value, for those from Punxsutawney cover only parts of three years and those from Grampian cover 45 years. The area is so small that the rainfall probably varies but little within its limits. Even if more figures were at hand they might not differ materially from those for Grampian. These figures indicate a well-watered area with a mean annual precipitation of nearly 45 inches. Rainfall has been as low as 26 inches and as high as 57 inches in this part of the State. The following table was compiled from the U. S. Weather Bureau "Climatological Data."

Average monthly rainfall in inches at four stations.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Grampian	3.56	3.40	3.93	3.41	4.29	4.19	4.93	4.00	3.20	2.79	3.06	3.61
Punxsutawney	4.93	3.12	3.60	3.01	5.30	4.77	4.04	5.93	2.93	5.44	2.59	3.31
Clearfield	3.84	2.69	3.57	3.41	4.78	5.06	4.00	5.14	3.78	2.32	2.84	3.09
Brookville	3.08	2.47	3.15	2.96	3.59	4.07	4.66	4.21	3.40	2.80	3.05	2.95

(a) Period represented is shown below.

Annual rainfall.

	Low	High	Mean
Grampian, 1864–1909,	32.46	57.50	44.37
Punxsutawney, 1913–1919*,			48.97
Clearfield, 1905–1924†,	33.23	60.88	45.52
Brookville,	26.23	55.48	41.06

*Records for 1913–1916 incomplete, for 1917–1919 complete.
†Records for years not complete except for 1914–1923.

According to the table, the highest precipitation is in June and August and the lowest in February and November. To show the variation in the monthly precipitation from year to year the records for Grampian by months for a number of years are given.

Monthly rainfall from 1895 to 1904 at Grampian, Pa., in inches.

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1895	5.19	0.96	1.90	3.81	2.38	2.87	2.85	3.08	2.20	1.26	2.57	3.48	32.55
1896	1.22	3.57	4.02	2.40	2.20	5.76	8.83	3.98	4.45	2.62	3.26	1.82	44.13
1897	2.15	2.78	4.25	4.14	4.55	3.14	7.02	2.46	3.16	.68	6.04	4.57	44.94
1898	3.81	2.06	8.40	2.30	3.30	5.03	3.41	4.12	1.54	5.21	3.55	3.56	46.29
1899	3.12	3.03	4.42	1.67	5.34	3.00	3.84	3.54	3.00	1.56	2.31	3.96	38.79
1900	3.21	3.63	3.64	1.36	2.77	4.13	5.18	3.76	2.75	3.32	4.71	2.40	40.86
1901	2.03	1.98	1.88	5.22	3.51	4.13	5.18	4.22	2.95	.26	3.74	3.30	38.40
1902	2.42	1.84	2.87	3.71	2.81	4.13	5.18	3.76	2.75	2.43	3.74	3.30	38.94
1903	2.89	4.64	4.89	3.72	2.51	4.98	5.15	4.94	1.98	4.55	3.74	3.30	47.29
1904	5.75	3.09	6.06	(a)	------	------	------	------	------	------	------	------	------
Mean	3.18	2.76	4.23	3.15	3.26	4.13	5.18	3.76	2.75	2.43	3.74	3.30	41.36

(a) No record.

The storm of May 30 and June 1, 1889 when rainfall in 32 hours at Grampian amounted to 8.6 inches, was very exceptional. That storm caused the high water which culminated in the Johnstown flood.

RUN-OFF

Part of the rainfall runs from the surface without sinking into the ground, part sinks into the ground but ultimately reaches the streams, and part evaporates, either directly from the surface or in the process of respiration by plants. There are no gaging stations in this area; two were established in October, 1913, just east of this area, for which records for one year are available. One of these stations is at Bower on Susquehanna River and the other at St. Lu on Chest Creek. Figures in the following table are quoted from the annual report of the Water Supply Commission of Pennsylvania for 1914, which report should be seen for the complete figures. The drainage area above Bower is estimated at 320 square miles.

Monthly discharge of the West Branch of Susquehanna River at Bower, Clearfield County, Pa.

Month	Discharge in second-feet			Run-off	
	Maximum	Minimum	Mean	Second-feet per square mile	Depth in inches
1913					
October, 2-31	2,300	66	488	1.525	1.700
November	4,440	155	784	2.450	2.733
December	1,140	163	353	1.103	1.272
1914a					
January	b4,920		553	1.728	1.992
February	b4,200		888	2.775	2.890
March	b5,550		1,240	3.875	4.468
April	3,720	466	1,250	3.906	4.358
May	3,900	79	658	2.056	2.370
June	797	60	178	0.556	0.621
July	236	60	109	0.341	0.397
August	150	48	70	0.219	0.253
September	71	40	47	0.147	0.164

(a) River frozen Jan. 13-28 inclusive and Feb. 8 to Mar. 16 inclusive and discharge during frozen period including March 17 and 18 estimated from climatological records and Bald Eagle Creek at Beech Creek.

(b) Estimated.

This record shows that the minimum discharge in a month varies from 40 second feet to more than ten times that, or 466 second feet, and the maximum from 71 second feet to 5,550 second feet. The total run-off was 26.3 inches out of a total rainfall of probably 40 inches, or over 60 per cent. It should be recognized that these figures cover a very short period and therefore should not be given too much weight. Discharge measurements are not given for the station at St. Lu, as not enough measurements had been made to serve as a basis for the preparation of a discharge table. The drainage from an area of 110 square miles above St. Lu is from ⅓ to ¼ of the discharge of the Susquehanna at Bower on the same day. Until more data are available the discharge may be assumed as roughly proportional to the areas of the drainage basins. Other gaging stations were also established at the same time at Clearfield on Susquehanna River and at Dimeling, on Clearfield Creek.

To check the figures given for Bower, discharge measurements made at Williamsport for 9 months of 1914 and for a number of previous years are given. The figures show the variation in run-off from year to year.

Discharge of West Branch of Susquehanna River at Williamsport, Pa.

Year	Discharge in second-feet			Run-off	
	Maximum	Minimum	Mean	Second-feet per square mile	Depth in inches
1895	58,900	410	6,282	1.10	12.60
1896	76,500	970	8,681	1.53	20.89
1897	53,000	600	8,295	1.47	19.99
1898	162,600	1,120	9,885	1.75	23.82
1899	68,800	600	7,971	1.41	19.19
1900	110,100	710	7,551	1.33	18.05
1901	150,900	1,120	10,606	1.88	25.63
1902	164,100	830	10,714	1.89	25.92
1903	110,700	1,280	11,715	2.07	27.98
1904	135,100	830	9,450	1.68	22.83
1905	111,100	1,610	12,000	2.00	20.77
1906	48,000	1,120	7,310	1.30	17.61
1907	96,600	630	8,830	1.57	21.40
1908	103,600	495	9,660	1.71	23.34
1909	141,000	------	8,040	1.44	19.34
1910	97,600	495	7,060	1.25	16.97
1911	87,600	2,310	12,300	2.18	29.50
1912	103,000	250	9,659	1.71	23.31
*1914	119,000	538	10,000	1.77	------

*To October.

These figures show variations by years of nearly 100 per cent, the run-off for 1911, for example, being nearly double that for 1895.

To illustrate further how the run-off varies from month to month there is given another table showing the mean monthly run-off at Williamsport for a few years.

Monthly discharge of West Branch of Susquehanna River at Williamsport, Pa., for the years 1896-1901, in second-feet.

Months	1896	1897	1898	1899	1900	1901
January	5,705	4,955	15,799	12,005	13,934	5,182
February	10,861	9,495	12,211	9,303	14,095	3,010
March	13,809	25,589	31,357	27,500	15,639	20,920
April	20,118	13,869	12,900	15,693	13,992	27,533
May	3,853	14,294	10,536	7,484	4,923	15,403
June	7,454	3,046	4,289	2,724	4,043	12,311
July	6,276	3,406	2,056	1,748	2,046	2,911
August	6,382	3,712	4,467	1,335	1,311	7,049
September	1,560	1,706	1,539	1,845	931	6,296
October	13,137	1,286	7,372	1,008	1,821	2,122
November	8,770	6,716	8,513	5,744	9,328	4,266
December	6,245	11,475	7,590	9,258	8,562	20,276
Annual mean	8,681	8,295	9,885	7,971	7,551	10,606

As indicated by the table, the maximum run-off is usually in March or April, though not always. The run-off through December to April inclusive is usually above the average and, for the rest of the months, below the average. December, January, and February

may, however, all run under the average, especially when the river has remained frozen; occasionally May or June or some other month may run above the average. The summer and fall months, while generally below the average, are variable from year to year; thus the October run-off in 1896 was more than 12 times that in 1899.

GROUND WATER

The ground water is that which has sunk into the ground. Afterwards it is returned to the surface, where it evaporates, runs out as springs, is taken up by plants, or is raised from wells for household or other uses. On first entering the ground it descends, following passages or pores in rocks until it reaches either an impervious stratum or the level of saturation, or water table as it is called. The impervious strata encountered in this area are most commonly the beds of clay that underlie the coal beds. Reaching such a layer, the water may follow it down the dip to its line of outcrop, where the water escapes in the form of springs or boggy ground. If, on the other hand, it first reaches the water table, it tends temporarily to raise the level of that table, causing increased outflow in the valleys where the water table reaches the surface. As the surface of the ground in this quadrangle, in its broader features, slopes in general in the same direction as the dip of the underlying rocks, the underground waters have the same direction of movement as the surface waters. In like manner, the water table follows the topography of the surface, though it is less rugged in shape. As a rule, it is near the surface in the valleys, where it coincides with the surface of streams, ponds and lakes, and is farther from the surface on the hills, where its distance from the surface is indicated by the water level in wells. This depth varies with the character of the surface, the character of the underlying rock, and the season. It will be nearer the surface in the broad flat areas than near sharp declivities where the water may drain away readily. It will be nearer the surface that is underlain by fine-grained rocks, such as shales, than that underlain by coarse-grained rocks like sandstone. The surface of the water table rises rapidly after heavy rains and then gradually sinks again as the water drains away.

In this area a large percentage of sandy strata, sandstones and sandy shales, permit a large absorption of the rainfall. This storage capacity equalizes to some extent the stream flow in summer. During rainy weather and for a time afterwards the streams carry more or less water that has flowed down the surface without entering the ground. During the drier seasons, practically all of the stream run-off has, for a greater or less time, been circulating underground.

Domestic supplies.

Domestic supplies in this area, aside from public supplies, are derived from wells and springs. The wells are either dug or driven, mainly dug. As far as noted, all of the wells of the region are shallow, the dug wells ranging, as a rule, from 10 to 30 feet deep. The driven wells in a few instances are nearly or quite 100 feet deep. The springs generally have a small flow though a few large springs were noted, some of the latter being used for town supplies.

The spring and well water of this region is soft and healthful except where polluted. A large proportion of the springs come from coal beds and may contain a high percentage of sulphur and iron. In a few instances, where springs are at sufficient elevation above the houses, the water is piped into the houses and, if the flow warrants, modern plumbing is installed. In a few places windmills and elevated tanks have been installed for household water supply. So far as was learned, the supply of water is abundant at all seasons.

Town supplies.

Most of the smaller towns depend exclusively on private wells and springs. Thus, Adrian is supplied by 17 wells, mostly dug, which range in depth from 14 to 47 feet. The wells at Burnside average 21 feet deep. Locally, as for example at Anita, a private well or spring has been made to serve the public, the owner being compensated for its upkeep by a remission of road taxes, or in some other way. The water supplies of the larger towns are briefly described as follows:

Punxsutawney: The supply for Punxsutawney is drawn from the east branch of Mahoning Creek, 8½ miles from town, from Clover Run 10 miles from town, and from one well 155¾ feet deep at the filter plant at the mouth of the east branch of Clover Run. The reservoirs have an impounding capacity of 45 million gallons. From the reservoirs the water is sent through a horizontal pressure filter. The elevation is sufficient to give the necessary pressure in town. In addition to the public supply, about 150 private wells are also used in town.

Glen Campbell: The supply is obtained from Brady Run about one-half mile east of town. The water is pumped from the reservoir of 50,000 gallons capacity to a pressure reservoir, from which it is distributed. A few private wells are also used.

Deep and artesian wells.

Artesian water should be found in the valleys in the axes of the synclines in this area. Such water should be looked for in the sandstones that outcrop above drainage on the anticlines and underlie

the valleys. Artesian wells have been obtained at Lumber City, near Clearfield, and one just west of Osceola Mills. The water in such wells is likely to be mineralized, as shown by a well sunk in the Curwensville syncline near Clearfield. That well struck a weak brine between 400 and 500 feet below the surface and a strong brine between 700 and 800 feet. A gallon of water weighed 8¾ pounds and contained two-thirds of a pound of salt, 84 gallons being required to furnish a bushel of salt. An analysis by Geo. H. Cook, of New Jersey, as given in the Second Geological Survey of Pennsylvania report H-7, page 140, is as follows:

Analysis of brine from Clearfield "oil" well.

Common salt	69.010
Chloride of Bittern, calcium	25.090
Chloride of Magnesian Bittern	5.900
	100.000
Water	88.952
Salt	7.591
Chloride Calcium	2.767
Chloride Magnesium	.655
Oxide of iron	.007
Silica and Earth	.028
	100.000

WATER POWER AND WATER STORAGE

Power

At the present time this area holds out little inducement for water power projects of any size. A few places may prove worthy of study in the future, particularly in connection with any scheme of water storage. Present interest will probably be in the possible utilization of some of the small streams of the region in the production of small quantities of power for local domestic use. In many sections of the countdy small streams are being used for generating electricity for lighting individual houses or groups of houses and for running machines on the farm and in the house. In many parts of this area the streams rise on the upland and flow from one to several miles before descending sharply to the main valley. Such streams have very small flow at most times and may go dry but, as the fall may amount to 100 or 200 feet in a quarter of a mile, it would seem that such streams might well be utilized by those through whose land they flow. To illustrate: according to

the topographic map, Rock Run, south of Glen Campbell, drains an area of 3 square miles and has a fall of 80 feet in the quarter of a mile just above its mouth. Assuming 80 per cent efficiency for a power installation, there is the equivalent of a little over 2 horsepower for each one-tenth inch run-off per square mile. This might be counted on to yield 10 horsepower through most of the year without storage. Whether such a project, or any other in this area, would be financially feasible, would depend upon the conditions at the power site as affecting the cost of installation and maintenance, and the quantity of power used. Where the power is needed only a part of the day, the use of storage batteries or small water storage may allow the maintenance of a much larger output during dry weather than would be supplied by the unconserved run-off.

In any discussions of water power it must be recognized that in any region situated as this is, in the heart of the coal field, cheap coal everywhere available, water power cannot compete with the coal because of the high cost of installation except where conditions are especially favorable. There are no waterfalls in the area but several streams, rising on the upland, descend sharply by a series of low cascades to their outlet valleys at a much lower level. To take advantage of such conditions always involves the building and maintenance of a flume of some length and of a penstock which, in most instances, will be expensive. The matter is presented here only as a suggestion.

Storage

In addition to the many possible small developments, a few larger developments may be feasible in the future. Most, if not all, of these projects involve dams of considerable length, usually at least 1,000 feet long on top (for a height of 60 to 100 feet). As such a dam would yield only a very limited amount of power, the largest present interest in such places must be as possible sites for impounding water for the benefit of stream navigation, larger power plants farther down the rivers, or for flood prevention. Among places of special interest in this connection are:

Little Mahoning Valley near Enterprise; top of dam 100 feet high, probably not over 1,000 feet long; or 180-foot dam, but length would be from 2,000 to 3,000 feet; area drained 36 square miles.

Bear Run, just above McGees Mills.

Ugly Run, above Rossiter Junction.

Possibly East Branch of Mahoning Creek near mouth of Clover Run.

None of the places mentioned were specifically examined for dam sites, and the suggestions are made mainly from recollections of the conditions at those points, supplemented by data from the maps and from photographs.

At the present time, there are a few water power developments of very minor importance, such as that on Ugly Run above Rossiter Junction.

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